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EMPIRE FRUIT.

AN interesting and valuable paper on the Empire Fruit Industry was read before the Royal Society of Arts, London, by Mr. W. G. Freeman on 23rd February. Some very striking statistics relating to the importation of fruit into the United Kingdom were presented, indicating that vast quantities of all kinds of fruits are consumed annually by its inhabitants, and that at least twenty-eight per cent. of the imports are derived from the Dominions and Colonies. Thus, in 1931, some fifty-six million pounds worth of fruit was consumed, of which but ten million pounds worth was produced in the country, the rest being imported from over-seas. In comparison with other foodstuffs, fruit has apparently come to occupy a very important place in the dietary of the nation. The value of the 1931 fruit importations exceeded by twelve million pounds the value of imported wheat and flour, and approximated to three-quarters of that of beef and mutton.

Perhaps the main reason for the greatly increased use of fruit in the United Kingdom is the efficiency of transport and refrigerating systems. Before rapid transport and safe methods of storage were possible, the only means whereby fruits indigenous to one region could be enjoyed by the inhabitants of a distant country was the actual introduction and cultivation of fruit-bearing plants. This had obvious limitations, and was naturally an expensive business.

The use of artificial ice in fruit storage started about 1880; before then natural ice was imported into the United Kingdom mainly from Norway. In 1900, however, ice was being made in ships carrying all kinds of perishable foodstuffs. Fruits require very special storage conditions; they have to be kept alive during the storage, but their biochemical processes, such as respiration, must not be entirely suspended. Moreover, disease organisms must be kept in check. These results can only be achieved by very careful attention to temperature, humidity and ventilation, and each kind of fruit requires a different environment in order to permit retarded respiration. Thus, bananas store well at 53°, oranges at 40°, pine-apples at 45°, and apples, generally speaking, at 33°F.

Bananas were introduced into the Canary Islands from China before 1500, nevertheless, they were exported to England only in very small quantities, and were almost unknown there even in 1830. The development of the banana trade began between Cuba and New York in the year 1804.

The first commercial importations into Europe, were made in 1878 from Madeira, and in 1882 from the Canary Islands. Central American bananas were transported to New York in 1896, and thence to England, but it was not until 1899, as the result of improved methods of refrigeration, that Central American and Jamaican (Gros Michel) bananas reached England in large quantities.

There have been two recent important developments in the banana trade. Firstly, owing to the ravages of Panama disease in Central America, efforts are now being directed to the breeding of a type of Gros Michel banana resistant to the disease. Secondly, attempts are being made to ascertain whether the Canary banana cannot be transported satisfactorily without crating. In these investigations the Imperial College of Tropical Agriculture is taking a very active part, thanks to financial assistance granted by the Empire Marketing Board, which has erected a Low Temperature Station at the College. As an outcome of the work on the Canary banana, planters in Trinidad and in other West Indian islands are seriously considering the possibilities of renewed production of the Canary banana for export. In Sierra Leone and the Gold Coast Colony, experimental banana cultivations have recently been started with a view to testing the possibilities of export trade.

Apples are second in importance (oranges coming first) among the fruits imported into the United Kingdom, reaching an annual value of about eight million pounds, nearly sixty per cent. of the imports coming from within the Empire. Successful shipments from Australia and New Zealand across the tropical belt, to European markets some twelve thousand miles distant, indicate the high efficiency of modern refrigerating systems with which the fruit ships are equipped. Through the activity of research workers of the Low Temperature Station at Cambridge, England, the incidence of "brown heart" which occasioned much anxiety in 1922 because of the severe losses it produced, has been largely eliminated. The cause of "brown heart" was definitely traced to excess of carbonic oxide in the atmosphere of the ships' holds.

The value of orange imports into the United Kingdom in 1931 was ten million pounds, about one-quarter being of Empire origin. The commercial orange is mainly a sub-tropical fruit. The United States of America and Spain are the principal orange-growing countries, but Spain supplies sixty per cent. of the world's export trade, whilst the United States sends abroad but seven per cent. of its production. In the British Empire, Palestine and South Africa possess large and increasing export trade, whilst oranges are also exported from Jamaica and Cyprus. Transport troubles with oranges are fewer than with apples. Wastage due to disease is largely eliminated by proper care in picking, packing and handling.

Grapefruit consumption in the United Kingdom has increased enormously during the last ten years, but Empire contribution is comparatively small. The principal producing regions are the Southern United States and the West Indies, but South Africa and Palestine also possess large and expanding industries. A Citrus Growers' Association was founded in Jamaica in 1930, and more recently, a similar association was inaugurated in Trinidad. Both are equipped with up-to-date packing sheds, and strict supervision of fruit for export is maintained. Elsewhere in the Empire, grapefruit would appear to offer opportunities for a new industry, as for example, Sierra Leone, Gold Coast Colony and British Honduras.

In the United Kingdom there is a large demand for lemons, probably owing to custom and taste. Most of the requirements are supplied by Italy, although South Africa and Palestine export lemons in small quantities. The small demand for limes is met by imports from the West Indies, but attempts to popularise the lime in Great Britain have so far achieved little success.

In addition to fresh fruits, enormous quantities of dried fruits, amounting to five million pounds value, are imported annually into the United Kingdom. Australia sends dried grapes, raisins and sultanas (two million pounds worth), and South Africa, dried prunes, plums and apricots.

Fruit pulps are not suited for long distance transport, and, so far, the Empire has supplied only small quantities, but canned fruits have been exported in increasing amounts during the last twelve years. The present value of canned fruits imported into the United Kingdom is about six million pounds, of which one million is spent on Empire pineapples, eighty per cent. of which is produced in British Malaya. Opportunities may exist for canned mangoes and guavas from the West Indies and elsewhere, but so far, no serious attempts to establish these new industries appear to have been made. The new Jamaica Citrus Growers' Association, however, has recently made shipments of canned grapefruit.

Several fruits of very attractive flavour still seek commercial exploitation. Among them may be mentioned the mango, avocado pear, papaw, sapodilla, mangosteen, custard apple, granadilla, persimmon and lichi. Many of these grow well in countries within the British Empire. Unfortunately they deteriorate rapidly on removal from cold storage, and their marketing is difficult and wasteful.

Finally, fruit juices deserve note; the value of their annual imports into the United Kingdom is about one-quarter of a million pounds. West Indies lime juice ranks foremost, but other citrus juices could doubtless be exported for manufacture into cordials and other beverages, provided suitable methods for shipping in bulk, for example, in a frozen condition, could be devised.

Mr. Freeman has paid deserved tribute to the biochemists, plant physiologists and engineers who have done so much to bring refrigeration and fruit storage to such a state of perfection. But we may add that the popularity of fruit in recent years has also been due, in no small measure, to the spread of knowledge concerning vitamins, with which

fresh fruits are richly endowed. Thus it is now known that oranges are of the greatest value as a source of vitamins, but apples are of minor importance. Lemon juice, contrary to earlier opinions, is said to be of more value as a source of the anti-scorbutic vitamin C than lime juice. Most fruits contain variable amounts of the anti-neuritic vitamin B. The difficulty at present is to be able to assess quickly and accurately the vitamin potency of any given material without recourse to trials on animals such as caged rats. Nevertheless, specific chemical tests for certain vitamins have already been evolved, and possibly further tests will be forthcoming. In such event, many questions still requiring solution will doubtless be answered, for example, at what stage of development do fruits contain most vitamin; is sunlight entirely necessary for the formation of certain fruit vitamins; is artificial irradiation necessary; are certain varieties of fruit more potent than others?

Along with advances in vitamin chemistry, further developments in refrigeration processes are pending. Thus, the use of "dry ice" (solid carbonic oxide) for procuring low temperatures has rapidly gained in importance during the last four years, and will doubtless rival ice in the refrigerating plants of the future. A more exact knowledge of subjects such as these will further encourage the demand and consumption of fruits, for, without doubt, we are beginning at last to realise that healthiness is within our reach through the careful selection of proper articles of diet.

RECENT WORK ON SUGAR-CANE SOILS.

[*Note.—We publish below an abstract copied from the "International Sugar Journal" for May*, 1932, *of a paper by Professor F. Hardy, presented at the International Sugar Conference, which was held at Puerto Rico during March*, 1932.—*Editor.*]

The significance of the soil profile in cane-field studies.—(*Bull.* 64.)

THE total area of cane lands in Trinidad is some 40,000 acres, and occupies three types of land, geologically-recent River Alluvium, Recent Swamp and Lagoon Alluvium, and Miocene Clays and Marls. Of the last, the Naparima clays weather pale red or brown at the surface with a blue-grey, mottled red sub-soil, and are stiff in wet weather with a highly acidic reaction; while the marl soils are black in the surface 1 to 2 feet and creamy white below with a neutral or alkaline reaction. These marl soils are the most fertile in the island.

Drainage studies.

Particulars are given of four sites in alluvium at which drainage tubes were sunk and measurements of the water level taken at intervals. The results showed that the water-table levels follow the surface contour, and in the wet season in no case was the mean level higher than the base of the side trenches, indicating a certain amount of underdrainage. Further, though the average depth of mean water-table, both in the wet and dry season, differs in each case, the lowering of the water-table level is not due to the side trenches but to inherent properties of the soil and situation. With regard to seasonal fluctuations, these follow closely the rainfall; rarely does the water-table rise to ground level, but it approaches it during wet spells. The soil possesses three zones, the zone of non-saturation, intermittent saturation and permanent saturation.

Relationships between drainage conditions and the soil profile.

Six feet pits were dug at the four sites and samples examined. The results are tabulated in detail, the particulars being given for each layer. The effects of underground water movements are clearly discernible, and the main features may be noted here.

Zone of Non-Saturation.

The soil is uniform in appearance and more or less friable to the bottom of the plough furrow, but below becomes faintly speckled and compact; the texture is slightly more clayey towards the base; the reaction is fairly uniform with a tendency to lower acidity in the middle layers; organic matter is low and diminishes rapidly below 15 inches; the carbon to nitrogen ratio is low and diminishes below; nutrient status is highest in the first few inches but fairly uniform below.

Zone of Intermittent Saturation.

The soil is markedly mottled with intensification of this character below; the texture differs little from that of the base of the former zone; the reaction is definitely more acidic; organic matter and the C/N ratios are much lower, as are also the nutrient values.

Zone of Permanent Saturation.

Apparently oxidizing conditions do not exist, and the soil is more or less uniformly blue-grey; texture differs little from that of the zone above; the reaction is less acidic than that of the top zone; organic matter and C/N ratios are lowest; nutrient values are relatively very high.

Thus the fluctuating ground-water has impressed certain definite features on the soil profile for which an explanation is offered, but a complication arises in periods of dry weather when the direction of transportation of soluble matter is reversed.

For comparison with these results, a series of determinations of *root distribution* were made at two of the sites by weight measurements of roots in successive six-inch cores. These indicate that three-quarters of the total root weight lies in each case in or above the top of the zone of intermittent saturation, and that a rather sudden increase in root weight occurs at the top of this zone. The more favourable site is that with the lowest water-table and deepest intermittent zone.

THE CACAO INDUSTRY OF TRINIDAD.

SOME ECONOMIC ASPECTS.

Part IV.

Historical 1870 to 1920.

By C. Y. Shephard.

In the previous article it was shown that, by 1870, cacao had become an important minor industry in Trinidad. The outlook, however, was by no means promising. Yields had been reduced by drought, prices were low, and most estates were unable to employ indentured labourers (7). These hindrances soon disappeared, and such a remarkable expansion followed that, by 1900, cacao had displaced sugar as the leading agricultural industry, and came to be regarded as the "financial barometer" of the Colony. Many factors, both external and internal, combined to effect this change. An indication has already been given of the important changes in manufacturing processes, which, together with substantial reductions in import duties in consuming countries, greatly stimulated the demand for cacao (7). Within the island, the elimination of squatters, coupled with facilities for the purchase of small-holdings, the depression in the sugar industry, the evolution of the "contract system", the provision of loans on mortgage, the construction of roads and railways, and the use of indentured immigrants, all served to facilitate the rapid extension of the cacao industry.

Squatting by "runaways" was prevalent during the days of slavery, and expeditions were frequently despatched into the interior of the island to destroy their camps (4). Even after emancipation the authorities remained bent on compelling the negroes to seek work on the estates. To achieve this object, they made every effort to prevent the legitimate acquisition of small-holdings, with the result that squatting increased. The situation remained unaltered until 1847, when, in response to outside pressure, the upset price of Crown Land was fixed at £2 per acre. This was regarded as an empty gesture, for the price was considered sufficiently high to prohibit the purchase of land by the labourers, and squatting continued. Twenty years later a more determined and sympathetic attempt was made to stamp out what had come to be regarded as an incurable evil, by facilitating the settlement of Crown Lands on reasonable terms. During the Governorship of Sir Arthur Gordon a survey of the Montserrat district revealed 400 squatters, the majority being peons of Spanish extraction, occupying areas given over to cacao, coffee, and provisions, varying in extent between 3 and 120 acres (6).

Montserrat was declared a Ward, and selected as the scene of the first experiment. The upset prices of ordinary and lagoon Crown Lands were reduced to £1 and 10s., respectively, per acre. The squatters were required, on pain of prosecution, to petition within six months for the lands they occupied. The occupiers were conceded the privilege of paying £1 in cash, or £2 by four equal annual instalments, for every acre of land, without being subjected to open competition. The procedure was carefully explained to each individual. The merchants, with whom the squatters dealt, were quite willing to advance the purchase money on mortgage, for it ensured a continuance of custom, and provided a profitable investment with sound security. Within five years every lot had been surveyed, the district was formed into a prosperous Ward, and only two squatters had to be ejected (9). The astonishing success of the scheme induced the Government to extend it to other districts, in which similar results were obtained. These measures proved of the greatest consequence, for they not only gave the first real impetus to the development of a large body of peasant cacao-proprietors, but also greatly facilitated the formation of the larger cacao estates. It is to be regretted that, at a later stage, the Government indulged in the indiscriminate sale of Crown Lands without due regard to the need for providing suitable transport facilities.

Soon the "cloud of perennial ruin" again threatened the sugar planters, for the beet-sugar industry of Europe, aided by protective tariffs and subsidies, began to undersell cane-sugar. This competition, first felt during the 'seventies, became severe during the 'eighties, and rendered the plight of the Trinidad sugar planters desperate during the 'nineties. Since the erection of larger factories afforded the most immediate and certain means of reducing costs of production, the individual proprietors, many of them French, were bought out by large English companies. This centralisation had important consequences, for the owners of the sugar estates and factories were no longer resident in the island. The sums derived from the sale of the small sugar estates were used to extend the cacao industry. Thus, during the 'seventies and 'eighties planters of European origin, the majority French, began to establish cacao estates in the Montserrat district. They each bought a number of small and adjacent cacao properties from the Spanish peasants, and then purchased contiguous areas of Crown Land, which they established in cacao by means of the "contract system" (8).

Under the "contract system" (1) the contractor agreed to plant out cacao and bring it into bearing on a given area, up to ten acres, but usually one quarrée (*i.e.*, 1,000 pickets, or $3\frac{1}{8}$ acres) in extent. The owner felled the forest, and the contractor cleared the land, lined it, and planted the cacao (usually 12 feet by 12 feet) and

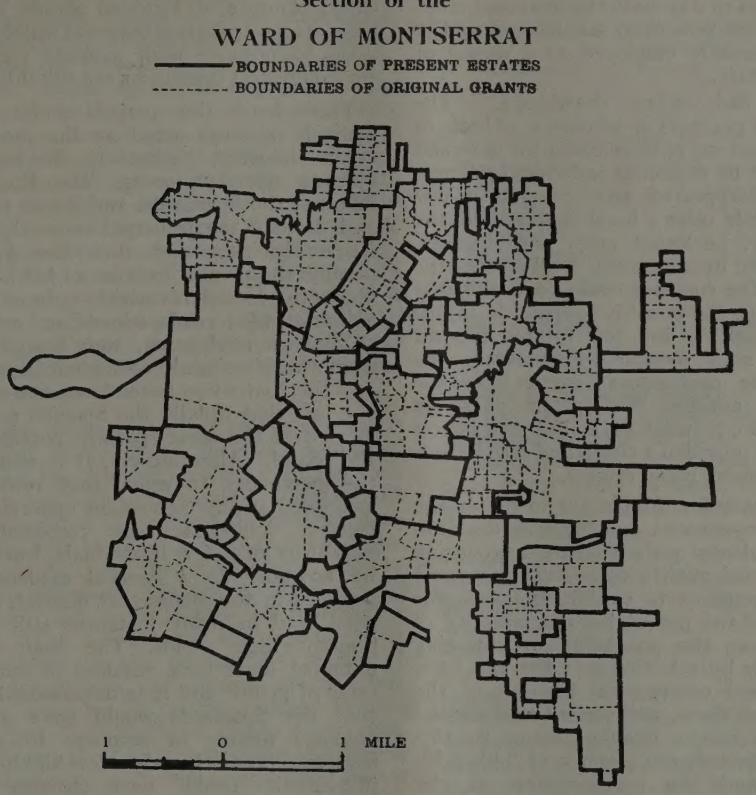

FIG. VI.—*This map illustrates the manner in which the great majority of Trinidad cacao estates were established. The areas indicated by broken lines represent either, small-holdings which were bought to form the nucleus of an estate, or, areas of Crown Land purchased to consolidate the estate. It will be noted that very few peasant proprietors remain in this particular area.*

immortelle shade trees (usually *Erythrina micropteryx*, or "Anauca", on the hill slopes, and *Erythrina glauca* or "Bocaré" on the flats, at a usual distance of 48 feet by 48 feet). The owner dug the main drains, but the contractor was required to spread the earth, and to keep these drains clear, and also to dig all the small drains. When the contract was taken over by the estate the owner paid the contractor an agreed price (usually 24 cents (1s.) but varying between 15 cents ($7\frac{1}{2}d.$) and 25 cents (1s. $0\frac{1}{2}d.$)) for each bearing tree, half that amount for each young tree in flower and not less than three years old, and one quarter of that amount for each supply or tree not less than two years old. No payment was made for "supplies" less than two years old, but the owner deducted the value of a bearing tree for each blank space.

The system was very satisfactory to the contractor for he was entitled to interplant the cacao with catch crops such as bananas, plantains, cassava, pigeon peas, cow-peas, tannias, beans, ground nuts, &c., which not only protected the young cacao and served as "ground shade", but also provided the contractor with food. Small quantities of surplus produce could be disposed of locally, though transport difficulties in a newly developing area usually restricted the extent of the market (2). He could obtain additional sums of money as a casual labourer on an estate, or by way of advances from the estate owner. In five years, which was the normal duration of a contract, the contractor obtained a sum sufficient to enable him to become a small proprietor. To-day nearly half the area under cacao is owned by small proprietors, many of whom began as cacao contractors. Some, it is true, preferred to squander their earnings in a brief period of "riotous living".

This system of establishing cacao suited the large planter equally well, for the expenses he incurred, before the contract matured, were relatively small, comprising the cost of the land, the felling of the forest, the digging of the main drains, advances to the contractor, and a few petty and miscellaneous items. The bearing cacao, which was taken over, provided security on which the owner could raise loans to pay the

contractor, and to erect the buildings and purchase the stock required to cope with the increased crop. Indeed, the system proved so satisfactory that it was almost invariably employed as a means of expanding an estate.

The system had certain drawbacks. The contractors were peasants or labourers, of little or no substance, and no redress could be obtained against the lazy or dishonest individual. Some, for example, disappeared after reaping a few catch crops, while others lined and spaced the trees irregularly, neglected pests and diseases, omitted to replace missing trees, or ill-treated the young cacao. The contract could be terminated only when serious, and possibly irreparable, injury had already resulted, and few estates escaped entirely some such damage. Fortunately the majority of the contractors, particularly the Spaniards who assisted the earlier phase of development, were industrious, skilful, and honest individuals, who provided a cheap and satisfactory means of establishing cacao estates.

It was customary for the planter to supply the contractor with cacao-seed, and the more discriminating owners selected pods from trees producing high yields of good quality cacao. The frequent failure of the progeny to exhibit the desirable characteristics of the parent led the majority of planters to ignore the possibility of obtaining high mean yields by selection. It has also been alleged that some contractors disposed of the material supplied them, and substituted hardier types producing inferior quality cacao. By this means, it is suggested, the number of "blanks" was reduced, and the remuneration of the contractor increased, for payment was in no way determined by the yield of the trees, or the quality of the cacao. While this ingenious method may have been resorted to by a few individuals, there is no evidence to suggest that this divergence of interests between owner and contractor was exploited in any general way. The fact is that the cacao trees of Trinidad are such extremely complex hybrids that a heavy bearing tree may give rise to progeny whose mean yield is much worse than the general average of cacao trees (3); moreover, environmental factors may produce similar results. As a result almost any kind of pod was used, and planters regarded the seed from one cacao tree as good as that from any other. It has recently been demonstrated, from work conducted by the Department of Agriculture at River Estate, that certain individual trees do produce progeny of high average yield, though, even so, there is no certainty that every individual offspring will prove a heavy bearer. The significance of this discovery will become more evident in subsequent articles, but it may be noted, at this stage, that vegetative propagation, which is almost universally employed in temperate orchard crops, in the case of cacao failed to obtain the general confidence of planters. Special attention is therefore being devoted, in the Cacao Research Scheme of the Imperial College of Tropical Agriculture, to new methods of propagation, involving the stock as well as the scion. The cacao planters of Trinidad should soon have at their disposal planting material which can be relied upon to produce high average yields provided environmental conditions are suitable.

Throughout the period under review the Spanish peasants acted as the pioneers of the cacao industry, repeatedly moving into, and opening up, new areas. The French planters followed the Spaniards, and began to consolidate and develop the principal cacao districts. It is frequently suggested that the Spanish peon became the pioneer because of his non-gregarious disposition, which invariably induced him to leave a district, when roads, schools, and other amenities of modern civilisation, were introduced. These events were certainly coincident in most districts, and the contention is rendered more plausible by the fact that usually the Spanish peasant is still located in the most sparsely populated parts of the island. Alternatively, it is maintained that the merchants, to whom they were mortgaged, foreclosed at any convenient opportunity. These factors, doubtless, were responsible for the migration of a few individuals, but they cannot be accepted as a general explanation. Their holdings in the Montserrat district, for example, gave, and in many instances still give, exceptionally high yields. The high prices then obtained must have resulted in extremely high rates of profit, and it is unreasonable to suppose that the Spaniards would have quitted these holdings merely in response to a pioneering instinct. Similarly only a few highly improvident individuals could have become financially embarrassed to such an extent as to render foreclosure either desirable, or possible. Moreover, the new owners were not members of the mercantile classes to whom these particular peasants were indebted. In fact, there is no conclusive or extensive evidence that the merchants ever conspired to obtain cacao properties by means of mortgages. Had this been their object it must be concluded that they proved singularly inept in their transactions. Almost invariably they were content to handle the produce, and possessed neither the aptitude, nor the inclination, to cultivate the properties themselves. Foreclosure was used, in the last resort, as a weapon to protect the security of the mortgagee.

The true explanation of these movements is that the Spanish peasant found them profitable. They appreciated the fact that, in Trinidad, a field of cacao generally produces its highest yields when between 15 and 25 years old.* This does not necessarily apply to the individual tree, nor need it be regarded as inevitable if a different policy of cultivation is adopted. The Spanish peon possessed an unerring eye for good cacao soil, and many of the holdings they originally selected, despite an appreciable decline in yield, still produce the heaviest crops. This selection of soils

* This point, which is of fundamental importance, will be discussed more fully in subsequent articles.

of outstanding merit resulted in that "string of lots . . . of every shape" along the Montserrat rivers, which so grievously offended the symmetrical eye of Sir Louis de Verteuil (9), but which was, nevertheless, sound agricultural practice. The peasants were able to sell out at extremely profitable prices, based upon the highest yield of the property. Thus, despite the lack of buildings, stock and other equipment necessary for estate cultivation, they often obtained $2.00 (8*s.* 4*d.*) to $2.40 (10*s.*) for each full bearing tree, compared with the generally accepted average of $1.00 (4*s.* 2*d.*).* They used the large sums realised by these sales to select areas of the best virgin soil in new districts, and repeated the process of selling when the highest yields were obtained, until most of the suitable areas of the island became established in cacao.

It has been shown that a few of the new cacao planters had fairly large financial resources, derived from the sale of their sugar estates, but the majority had little or no capital. Considerable sums were required to purchase the nucleus of an estate, along with areas of Crown Lands for future development, to pay the contractors, and to provide the necessary equipment. This capital was acquired, almost invariably, by mortgaging the estate. The interests of the merchants in securing control of the produce by means of mortgages are obvious, and common practice, but mortgagees were by no means confined to this class; in fact, individuals of almost every class sought to invest their savings in cacao mortgages. The inducement lay in the highly profitable nature of the crop, and the sound security which the industry appeared to offer. From 1870 to 1920 cacao realised an average of nearly $14.00 (£2 18*s.* 4*d.*) a fanega. High prices, high yields, and low wages, combined to make this period the golden age of the Trinidad cacao industry. The sale of the small sugar estates to English companies, the profits of other industries, the savings of individuals in varied occupations, and the wealth derived from the cacao industry itself, rendered large sums of money available for investment in cacao mortgages. These loans bore interest at rates which were generally between six and 12 per cent. per annum, varying according to the reputation of the district and mortgagor, and the size of the property. Cacao mortgages came to be regarded, with some justification, as "gilt-edged" securities, offering an attractively high rate of interest. Consequently any planter of integrity and skill—and some of neither—could obtain loans on mortgage without the slightest difficulty.

* Cacao estates were valued by placing an arbitrary value on the full-bearing tree, and multiplying by the number of such trees. There was no separate assessment for buildings, stock and other equipment, but any amount necessary to render them adequate and put them in good repair, was deducted from the total valuation. This method of valuation, together with others, will be discussed in a later article.

Table V.

*Average Annual Price (at store) of Trinidad Cacao per fanega.**

	$	£	s.	d.
1874-79	13.25	2	15	2½
1880-89	14.53	3	0	6½
1890-99	13.08	2	14	6
1900-09/10	13.73	2	17	2½
1910/11-1919/20	13.91	2	17	11½
1874-1920/21	13.90	2	17	11

With an abundant supply of cheap land, the aid of the contract system, and the apparently unlimited capital available on mortgage, an inadequate supply of labour seemed to be the only factor likely to limit the expansion of the industry. The problem had been solved, in the case of the sugar estates, by East Indian† indentured immigration which was controlled by ordinances specially designed to suit the sugar planters' requirements. The cacao estates were scattered, and small in area, and provided employment for only one labourer to every five acres of cacao. The sugar estates, in contrast, were concentrated, extensive in area, and employed a labourer for every acre under sugar-cane. Few individual cacao estates were able to meet the cost of providing for the regular visits of a registered medical practitioner, and hospital accommodation as required by the Immigration Ordinance (5). As, eventually, 80 per cent. of the labourers employed on the sugar estates were East Indians, many West Indians became available for the cacao estates. Some West Indians retained an interest in the sugar industry by growing cane for sale to the sugar factories. The numbers diverted from the sugar, to the cacao, estates were insufficient to meet the rapidly growing requirements of the cacao industry.

* The prices quoted were obtained from a large private firm (1874 to 1908) and the Cocoa Planters' Association (1908/09 to 1919/20; July to June, except for the period 1908/09 to 1912/13, when the financial year ran from 1st October to 30th September, and the nine months from 1st October, 1913, to 30th June, 1914). The private firm's quotations are for all grades of cacao, whereas the "C.P.A." prices are for Plantation or fermented cacao only. The prices from 1908/09 to 1919/20, therefore, are higher than they would have been if a portion of ordinary or unfermented cacao had been included.

† In Trinidad the term "East Indian" is used to denote an individual born in India, or elsewhere, of Indian parents. East Indians born in the West Indies are sometimes referred to as "Creole East Indians". Any other individual born in the West Indies is referred to as a "Creole" or "West Indian", qualified sometimes by a prefix, *e.g.*, French or Spanish, to denote his ancestry.

When a number of large and adjacent cacao properties became established in the Montserrat district, the planters petitioned for, and obtained, permission to group estates for the purpose of complying with the medical requirements of the Immigration Ordinance. Similar measures were adopted in other areas, and, with the aid of indentured labourers, the industry developed at a very rapid rate. The immigrants were indentured to individual estates for five years, and were provided with barrack-rooms free of charge. During this period they could be required to work for five days a week at any agricultural operation determined by the manager. For each day's work they were entitled to 25 cents (1*s.* 0½*d.*), compared with the general rates of 35 cents to 50 cents (1*s.* 5½*d.* to 2*s.* 1*d.*) for men, and 25 cents to 35 cents (1*s.* 0½*d.* to 1*s.* 5½*d.*) for women. Though these small wages by no means represented the entire cost of the immigrant's services, the estates, nevertheless, enjoyed a cheap, adequate, industrious, and amenable labour force, which greatly accelerated the rise of the most lucrative cacao industry.

The planters soon found that, although they had to pay 6 to 12 per cent. on borrowed capital, their young estates readily yielded a profit of 15 to 20 per cent. This had important consequences. The planters appreciated that by repeatedly extending their cacao acreage on borrowed capital, they could greatly increase their net incomes. Instead of concentrating upon the acquisition of a single estate free of encumbrances, as they might have done without inconvenience, they endeavoured to secure several estates, and even extended their cacao cultivation to areas which could remain profitable only with the maintenance of high prices. The fact that highly profitable prices were obtained for 50 years made the policy appear quite reasonable and sound.

This procedure was made possible by the willingness, and in many cases the eagerness, of mortgagees to postpone, indefinitely, the period of repayment. Cacao mortgages offered a much higher rate of interest than other "gilt-edged" securities, and the ability of the mortgagor to repay in part, or in full, confirmed the impression that the investment was thoroughly safe, and convinced the mortgagee that it was undesirable to require or accept liquidation of the loan. Hence, although the original loan was usually for a period of five years, the mortgagors were allowed, and even encouraged, to extend the period without definite renewal. In this manner the mortgagees rendered themselves liable to immediate foreclosure.

The receipt of large and regular incomes, and the absence of pressure for the repayment of capital indebtedness, lulled the planters into a false sense of security, and induced them to ignore the fundamental changes that were taking place. Except to the discerning few, the assumption that high yields and prices would be maintained indefinitely, appeared to be well founded. The owners of cacao estates were encouraged to adopt an extravagant mode of living, and entertainment was conducted in a liberal and costly style. Large families were fashionable, and the children were educated at the best or most expensive public and private schools in England or France. Expensive visits to Europe were frequently undertaken. The mortgagees for their part, exercised little supervision over their securities as long as the interest was regularly paid. In fact the industry was so profitable that many individuals failed to exercise any discrimination in selecting properties in which to invest their money on mortgage.

Under these extremely favourable conditions cacao cultivation spread throughout the island. In 1870 the area under cacao was about 19,000 acres, of which more than four-fifths were located in the two counties of St. George and Caroni*, principally in the valleys of the Northern Range, and along the banks of the Caroni River. No less than three-fifths of the total acreage under cacao was concentrated in the county of St. George. During the next 50 years the area under cacao cultivation expanded rapidly in every county. In 1920 the total area was recorded as 200,000 acres, of which St. Andrew accounted for 42,000 acres, or one-fifth. Caroni, St. George, Victoria, and St. Patrick, each had areas of about 30,000 acres (10). In fact, every county had become deeply interested in the production of cacao.

The growth in the importance of the industry may be gauged by a statistical comparison between the ten years 1870 to 1879, and 1910 to 1919. The quantities exported rose from an annual average of 8,000,000 lb. to 56,000,000 lb., the value of the exports from £241,876 to £1,553,000, and the percentage of the total exports, by value, from 14 to 31 (10). The price of cacao remained consistently high, averaging $14.00 (£2 18*s.* 4*d.*) throughout the period, culminating in an average of $23.92 (£4 19*s.* 8*d.*) in 1919-20. In 1920 appreciable areas were being laid down to cacao but many individuals could not tolerate the delay in bringing new areas into bearing, and purchased existing estates at fabulous prices. The high prices realised after the war were regarded as the beginning of a new era of unprecedented prosperity. Most people of means were interested, to a greater or less extent, in the industry, and, with "the financial barometer of the island" "set fair", the future was regarded with the most pleasurable anticipation.

Acknowledgments.

The writer is indebted to Miss P. Atteck of the Department of Agriculture for preparing, with the kind consent of the Director, the map of a section of the Montserrat Ward.

* For the location of the various Counties see Part I, Figure I.

Table VI.

Exports of Trinidad Cacao and Sugar, 1870-79 to 1910-19 (11).

	Cacao.			Sugar.		Total Exports.
	Lb.	£	Per cent. of Total Exports.	£	Per cent. of Total Exports.	£
1870-79	8,445,063	241,876	14.33	809,193	47.95	1,687,746
1880-89	13,759,763	392,398	16.84	758,029	32.53	2,330,058
1890-99	23,384,545	575,331	26.24	647,537	29.53	2,192,670
1900-09	40,146,154	1,030,550	36.91	500,075	17.91	2,792,382
1910-19	55,803,960	1,553,155	30.90	841,692	16.74	5,026,758
1920	62,741,172	3,226,215	43.39	2,656,625	35.73	7,435,361

Table VII.

Acreage under Cacao in Trinidad and Tobago by Counties (11).*

	1871 Acres.	1879 Acres.	1890 Acres.	1900 Acres.	1909-10		1920	
					Acres.	Yield in 1,000 lb.	Acres.	Yield in 1,000 lb.
St. George	11,731	15,324	?	?	91,145	16,458	32,365	6,499
Caroni	3,739	4,485	?	?	54,265	14,856	33,286	12,667
St. David	1,637	2,810	?	?	18,100	3,360	11,045	2,176
St. Andrew	....	....	?	?	52,600	9,336	41,910	11,109
Nariva-Mayaro	241	421	?	?	5,362	567	14,087	3,288
Victoria	662	705	?	?	33,300	3,773	30,002	7,059
St. Patrick	925	1,443	?	?	26,928	3,987	29,350	3,479
Tobago	?	?	?	?	8,500	669	8,207	1,778
Total	18,935	25,188	94,500	190,000	290,200	53,006	200,252	48,055

* *The acreages under different crops are compiled by the administrative officers in charge of the various Wards. Prior to 1916 no care appears to have been exercised in collecting these statistics. On 19th April, 1916, Sir Norman Lamont, Bt., drew the attention of the Board of Agriculture to numerous glaring errors which had been allowed to creep into these returns. An Inspector of Wardens was appointed, and new instructions were issued for the compilation of acreages. From 1917 these statistics may be regarded as reasonably accurate. In the official returns the area under cacao is recorded as 354,237 acres in 1915, and 232,533 acres in 1917. The apparent reduction of more than 100,000 acres of cacao is due, almost entirely, to the greater accuracy of the 1917 returns, and not to the wholesale cutting down of cacao trees.*

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MANURIAL EXPERIMENTS WITH SUGAR-CANE.

III.—An Analysis of an Estate Experiment to Determine the Effect of Sulphate of Potash on Yield of Sugar-Cane (Plant Canes), with Especial Reference to the Design of Layout.

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[*This paper was read at the Fourth International Congress of Sugar-Cane Technologists held in Porto Rico in March*, 1932 (10).]

I.—Introduction.

The experiment to be described is one of several (8) laid down in Trinidad to determine the effect on yield of sugar-cane of an application of sulphate of potash in the presence of a basic dressing of ground limestone, pen manure and sulphate of ammonia. It is taken as the subject of this paper because it affords interesting data with respect to :—

(1) A type of layout which, when somewhat modified, is suited to simple manurial trials on estates possessing no special facilities for experimental work in the field.

(2) Conditions under which degenerated soils containing small quantities of exchangeable or "available" potash respond to applications of potash manures.

Previous experiments in Trinidad to determine the effect of potash on the yield of sugar-cane have given very inconsistent results (5), (13).

II.—Details of the Experiment.

A complete field, containing 44 beds, was set aside for the experiment.

Cane Variety and Age.—B.H. 10/12, plant canes.

Soil Type.—River Alluvium (4), (7).

Tillage Treatment.—Cattle-ploughed (September, 1929).

Manurial Treatments.

(1) Basic treatments (given to all plots).

(*a*) Ground limestone, 3 tons to the acre (September, 1929).

(*b*) *Pen manure, 14 tons to the acre (December, 1929).

(*c*) Sulphate of ammonia, 4 cwts. to the acre in two applications, 1 cwt. (December, 1929). 3 cwts. (June, 1930).

(2) Potash treatment (to certain plots only). Sulphate of potash (91 per cent. purity), 2 cwts. to the acre (November, 1929).

Layout.

The permanent cane beds were used as plots.

(1) Every fourth bed received no sulphate of potash. The remaining beds received potash.

(2) Dimensions of beds, 22 feet by 396 feet = 1/5 acre.

* The pen manure was prepared according to the Mauritius method (1).

Age of Plant Canes on Reaping.—19 months.

Previous History of Experimental Area.

There is no evidence in the estate records that potash manures had previously been applied to this area.

III.—The Yield Data.

The canes from each of the 44 beds were separately reaped and weighed. The weights are recorded in Table I. Weighings were made to the nearest quarter (28 lb.)

Table I.—Actual Yields of Plant Canes per bed, in quarters of 28 lb.

Experiment A.

2 cwts. K_2SO_4 per acre.						No K_2SO_4.	
Bed.	Yield.	Bed.	Yield.	Bed.	Yield.	Bed.	Yield.
1	**717**	15	691	30	659	4	641
2	721	**17**	**630**	31	512	8	568
3	699	**18**	**656**	**33**	**597**	12	597
5	**767**	**19**	**668**	**34**	**673**	16	545
6	**699**	21	661	35	468	20	576
7	736	22	703	37	748	24	694
9	677	23	682	38	737	28	578
10	**646**	25	588	39	805	32	562
11	618	26	645	**41**	**755**	36	547
13	692	27	629	**42**	**766**	40	591
14	740	**29**	**647**	**43**	**769**	**44**	**639**

	Qrs. per plot.	Cwts. per acre
Mean Yield from plots with sulphate of potash	678.8	848.5
Mean Yield from plots without sulphate of potash	594.4	743.0
Difference in Mean Yields	84.4	105.5

IV.—Analysis of Yield Data.

There are given in this section analyses, by three different methods, of the data in Table I. In Section V are discussed the conclusions to which the analyses give rise, with respect both to the conditions under which significant results may be expected from the layout as it stands, and to the manner in which it might be modified with advantage.

Method I.

The standard errors of the mean yields from the plots with and without potash (σ_1 and σ_2, respectively) are separately determined, and the standard error of the difference (σ) calculated from the formula $\sigma = \sqrt{\sigma_1^2 + \sigma_2^2}$

Standard Error of Mean Yield per plot receiving potash (based on 33 plots) =72.0 qrs.

Standard Error of Mean Yield per plot without potash (11 plots) .. ..=46.0 qrs.

Standard Error of the Difference in Mean Yields $=\sqrt{(72)^2 + (46)^2}$
=85.4 qrs.

According to Method I, *the difference of* 84.4 *qrs. per plot* between the mean yields is less than the standard error of the difference of 85.4 qrs. and *is therefore definitely not statistically significant.*

Method II.

The mean yields (K_1) for the sulphate of potash plots immediately to the left and right of each plot without sulphate of potash (K_0) are determined (*e.g.*, plots 3 and 5, 7 and 9, &c.) The difference ($K_1 - K_0$) between each mean for the two plots (K_1) and the no-potash plot between them (K_0) is found, and the standard error calculated of the set of ten differences thus obtained.

Table II.—Values for $K_1 - K_0$ in quarters per one-fifth acre.

	1	2	3	4	5	6	7	8	9	10
$K_1 - K_0$	92	138.5	58	115.5	88.5	−59	60	−7.5	61	189

Mean Value for $K_1 - K_0$ .... = 73.6 qrs.
S.E. of Mean Value .... = 66.8 qrs.

According to Method II *the mean difference in yield of* 73.6 *qrs. per plot* is larger than its standard error of 66.8 qrs. The difference *is suggestive* therefore, *but not statistically significant.*

Method III.

For the purpose of this method of analysis certain of the plots are disregarded, in a manner such that the remainder constitute a series of randomised blocks. Each block contains three plots, two receiving sulphate of potash and one without sulphate of potash. The choice and arrangement of the plots in the blocks was determined as follows :—

The figures 1, 2 and 3 were drawn at random, each figure being replaced before the next drawing. Eleven drawings in all were made, corresponding to the maximum number of plots without potash. The figures thus selected were shuffled and drawn again, the order of their appearance being—

3, 2, 2, 3, 1, 2, 3, 3, 2, 3, 1.

The first selection gave the number of times the plots without potash should occupy the first, second and third positions in the blocks. This happened to be twice, four times and five times, respectively. The second drawing gave the position of the no-potash plot, with respect to the other two plots in Blocks I, II . . . XI, in order.

In accordance with this arrangement, beginning from Bed No. 1, plots were omitted until two potash plots were immediately followed by a no-potash plot, the latter thus occupying the third position in the first block. Plots following this no-potash plot were then disregarded, until a no-potash plot occurred between two potash plots, and so on*. In this manner ten "randomised" blocks were obtained. The excluded plots are printed in heavy type in Table I.

It should be noted that the plot positions were not shuffled. The net result of the procedure is to exclude, at random (with certain restrictions), 14 plots, the remaining 30 being taken in the order in which they occur. The advantage of this procedure lies in the fact that Fisher's Analysis of Variance (2) may now be used in the examination of the yield data.

The yields of sugar-cane from the selected plots are presented in a more suitable form for this analysis in Table III.

Table III.—Yields of Plant Canes per one-fifth acre in qrs. of 28 lb. less 660 qrs.

Block.	Treatment.			Total.
	Sulphate of Potash.		None.	
I	61	39	− 19	81
II	76	17	− 92	1
III	− 42	32	− 63	− 73
IV	80	31	−115	− 4
V	1	43	− 84	− 40
VI	22	− 72	34	− 16
VII	− 15	− 31	− 82	−128
VIII	− 1	−148	− 98	−247
IX	−192	88	−113	−217
X	77	145	− 69	153
Total	67	144	−701	−490
	211			

General Mean= − 16.33

* Beds with inequalities which render them unsuitable as plots could be discarded in a somewhat similar manner when laying out an experiment.

Table IV.—Analysis of Variance (2).

Due to	Degrees of Freedom.	Sum of Squares.	Mean Square.	$\frac{1}{2}\log_e$ (Mean Square).
Blocks	9	45,882	5,098.0	
Treatments	1	43,363	43,363.0	1.8848
Error	9 } 19 10	94,396	4,968.2	0.8015
Total	29	183,641		

Standard Error of a single plot $=\sqrt{4968.2}$

Standard Error (mean of 10 plots) $=\sqrt{496.82}=$ 22.29 or 3.46 per cent. of the mean yield of (660−16.33), or 643.7 qrs.

Results of Analysis.

According to this method of analysis the effect on yield of treatment with sulphate of potash is certainly significant. For $n_1=1$, and $n_2=19$, the one per cent. point in Fisher's table of z (2) is 1.0511. The difference due to treatment in Table IV is 1.8848—0.8015, or 1.0833. A difference of this amount might occur by chance less than once in 100 trials.

Final Analysis.

Table V.—Mean Yields of Plant Canes per acre. (cwt. of 112 lb.)

Treatment.		Difference.*	Standard Error of Difference.
2 cwt. K_2SO_4	No K_2SO_4		
838.1	737.4	100.7	39.40

For P=0.05, t=2.093 when n=19 (2). A difference to be significant must therefore exceed $2.093\times39.4=82.5$ cwt.

For P=0.01, t=2.861 when n=19. The significant difference then equals $2.861\times39.4=112.7$ cwt.

According to Method III *the difference of 100.7 cwts. per acre in favour of the canes receiving sulphate of potash, is undoubtedly significant.*

* It will be noted that a closer estimate of the mean difference in yield, as calculated from the complete set of data, is obtained by selecting the plots on the basis of 'controlled randomisation' (Method III), than by comparing the mean yield of the plots without sulphate of potash with that of the plots immediately to their right and left (Method II).

V.—Discussion.

(1) Type of Layout.

Effect of Design of Layout on Significance of Difference due to Treatment.

The increment in yield of sugar-cane to the acre, due to treatment with sulphate of potash, is approximately five long tons. This is equivalent to approximately 0.5 ton of sugar.

In the experiment the plots are laid out in regular order. Of the three methods of analysis, therefore, the first or second only can validly be used for the examination of the complete set of data as they stand. Although the difference in yield due to treatment with potash is large, and equal to 12.8 per cent. of the mean yield for all plots, by neither method is it statistically significant.

The increment in yield is shown definitely to be significant by the analysis of variance, however, when certain plots are disregarded in a manner such that the remainder constitute a series of randomised blocks. This is due to the fact that the arrangement at random in blocks enables a part of the error due to soil variation to be estimated and eliminated (2), (3). It can be seen from Table IV that the variation (sum of squares) due to soil differences between blocks is as large in this experiment as the variation due to treatment differences between plots. The variation between blocks in no way affects the comparison of treatments, and when allowance is made for it by means of the "analysis of variance", the difference of five tons per acre becomes significant.

There can be little doubt, therefore, of the advantages which accrue from the use of a randomised layout. The initiation of such a layout incurs little additional trouble, especially if the permanent cane beds are used as plots. It has already been adopted with success by the estate in question, and by other estates which possess no special facilities for experimental work in the field.

The superiority of a randomised arrangement, in comparison with a regular layout, is emphasised when account is taken of three other experiments set up on the same estate, which are identical in aim and nature with the one described. The mean difference in yield for a total of 86 plots receiving potash and 43 plots without potash, in the four experiments, using the second method of analysis, is 77.2 qrs. per plot of 1/5 acre (96.5 cwts. per acre). The standard error of the mean difference in yield by this method is 61.8 qrs. per plot (77.25 cwts. per acre). In spite of the large number of replicates of each treatment the difference remains statistically not significant. It therefore seems doubtful, under the conditions which obtain, whether it is feasible to lay down sufficient replicates to get a difference which is statistically significant by a layout of this nature. On the

other hand, when plots are discarded in the manner outlined in Method III, and the analysis of variance applied to the remaining data, the difference in yield due to treatment with sulphate of potash becomes undoubtedly significant in each separate experiment (Table VI).

Table VI.—Mean Yields of Plant Canes per acre (cwt. of 112 lb.)

Experiments A, B, C and D.

Experiment.	Mean Yield per acre.		Difference.	Standard Error of Difference.
	2 cwt. K_2SO_4.	No K_2SO_4.		
A	838.1	737.4	100.7	39.4
B*	863.3	764.1	99.2	24.8
C	841.25	737.5	103.75	38.8
D	731.7	661.1	70.6	29.7
Mean	818.6	725.0	93.6	—

From the following formula (2) an estimate may be made of the number of replicates required for a difference in yield to be statistically significant.

Taking the Significant Difference to equal $3\sqrt{x/y}$ where y = number of replicates required, and $\sqrt{x}$ standard error of a single plot, and substituting the values obtained in Experiment A, *by the third method of analysis*, for the significant difference and for x,

$$82.5 = 3\sqrt{(4968.2)/y}$$

Whence $y = 7$.

With a randomised layout seven replicates of each treatment appear all that are necessary to demonstrate that the difference is statistically significant, whereas, with a regular layout, 43 seem inadequate. The adoption of a randomised layout could therefore result in considerable economy in time, trouble, labour and area.

Plot Size and Shape.

In all four experiments each plot occupies the whole length of a cane bed in the field. In Experiments A, C and D the plot area is 1/5 acre, with a ratio of length to width of 18 to 1. In Experiment B it is 1/3 acre, with a ratio of length to width of 30 to 1. The use of long and narrow plots of relatively large area is discussed in another paper published in *Tropical Agriculture* (9). Such plots have been successfully used in Trinidad for cultivation experiments.

Conditions Determining Response in Yield to Potash.

Sugar-cane has been grown continuously on the soils of the experimental areas for approximately 100 years, with the exception of relatively short intervals between successive plantings during which the land was abandoned to bush. Until recently these soils have received the minimum of cultivation, and little or no manurial treatment. In consequence of such exhaustive methods of agriculture, the soils have lost their tilth and have developed a high degree of acidity. In addition they are probably much depleted in plant food.

During the last few years definite steps have been taken to apply remedial measures to these soils. For example, they have been liberally limed, and nitrogenous and organic manures are applied as a matter of routine practice. In addition, modern methods of cultivation have been introduced. The response to these measures in the form of enhanced returns of sugar to the acre has been obvious. The potash experiments described in this paper are a part of the general scheme of amelioration which aims at restoring to the soils some portion of the fertility which in all probability they originally possessed.*

The content of exchangeable potash of the top foot of soil of the four experimental areas is recorded in Table VII. Each figure is the mean value for ten or more samples taken from the plots which received no treatment with sulphate of potash.

Table VII.—Content of Exchangeable Potash of the Soils of the Experimental Areas.

Experiment.	A	B	C	D
Exchangeable K_2O (mg.E. per cent.)	0.22	0.12	0.21	0.28

The content of a typical, unmanured, Rothamsted soil is 0.34 mg.E. per cent. (6). By comparison the Trinidad soils appear somewhat deficient in this form of the base.

The basic dressing given to *all the plots* includes 4 cwt. of sulphate of ammonia and 10 tons of pen manure. A typical specimen of Trinidad pen manure contains 0.63 per cent. of K_2O, 0.44 per cent. of nitrogen and 0.20 per cent. of P_2O_5. The pen manure dressing therefore corresponds to an application of about 200 lb. of K_2O, 140 lb. of nitrogen and 63 lb. of P_2O_5.

The main conclusions which can be drawn from the potash experiments are therefore as follows :—

(1) *The 200 lb. of K_2O present in the dressing of pen manure appears inadequate to the needs of the plant, on these degenerated soils, when 4 cwt. of sulphate of ammonia also are applied.*

(2) *Under the conditions of the experiment there is a definite response, amounting to 5 tons of cane to the acre, to an additional application of 2 cwt. of potash as sulphate.*

* In this experiment applications of 2½ tons of sheep manure were made to the acre, instead of 14 tons of pen manure.

* de Verteuil (12), in the second edition of his book on Trinidad, published in 1884, states: "In good soils canes ratoon for seven or eight years; in superior virgin land newly cleared, for 15 years and upwards." On the estate in question canes now ratoon for one or two years only.

These conclusions are of the utmost importance in relation to the manurial treatment of plant canes in Trinidad. Until recently it has been the practice to apply to plant canes a minimum dressing of 20 tons of pen manure to the acre. As the island supply of pen manure is quite inadequate to meet the demands of so generous an application (11), it is gradually becoming the custom to reduce the dose to 10 to 15 tons in order that all plant canes may receive the benefit of an organic manure, and to make up for the reduced dressing by a general application of sulphate of ammonia. In consequence of this change in procedure an urgent need exists for a chain of potash experiments, of the modified type described on the various soil types of the cane-growing regions, to determine whether the supply of potash from the reduced dose of pen manure is sufficient to meet the needs of plant canes.

Summary.

I.—An estate experiment designed to determine the effect of sulphate of potash on the yield of plant canes, in the presence of a basic dressing of ground limestone, pen manure and sulphate of ammonia, is described. The experiment is a simple one, in which the permanent cane beds are used as plots, and the treatments are arranged in regular order.

It is shown that :—

(1) Although the pen manure in the basic dressing contains a considerable amount of potash, an additional application of 2 cwts. of potash, as sulphate, to the acre, gives an increment in yield of five long tons of cane. The increment is equal to 13 per cent. of the mean yield from all plots.

(2) This difference in yield cannot be demonstrated to be statistically significant with the regular layout used, whereas, when certain plots are disregarded in a manner such that the remainder constitute a series of randomised blocks, the probability that it might be due to chance is less than 1 in 100.

(3) With a randomised layout, seven replicates of each treatment appear all that are necessary to demonstrate the significance of the difference. With a regular layout 43 seem inadequate under the circumstances of the experiment.

(4) In view of these arguments the adoption of a randomised layout could result in a saving of time, trouble, labour and area.

(5) Such layouts have already been initiated with success on plantations in Trinidad.

II.—Conditions determining the response to potash of the degenerated soils of the experimental area are discussed, and the urgent need which exists for a chain of potash experiments, of the modified type described, on the various soil types of the cane-growing areas of Trinidad, is emphasised.

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BOOKS RECEIVED.

We have to acknowledge with thanks the receipt of the following book which has been presented to the Library :—

Principles of Soil Microbiology, 2nd Edition. Selman A. Waksman, pp. xxviii, 894, 1931. *Messrs. Bailliere, Tindall & Cox.*

GROUNDNUT ROSETTE DISEASE IN THE GAMBIA.

By T. R. Hayes, M.Sc. (Tech.), A.I.C.T.A.

Introduction.

Groundnut Rosette, which belongs to the Virus group of diseases, has attracted increasing attention during the last few years. No record of its existence in the New World appears to have been published, but it occurs in numerous parts of Africa and India; in particular, various authors comment on the increasing importance of the disease in Senegal (7), Java (8), Madagascar (9), and South Africa (4).

Storey and Bottomley (4) have given the most complete account of the disease which they successfully transmitted by means of infected specimens of *Aphis leguminosae* and by grafting, but in no other way. In Sierra Leone and Uganda the insect vector is thought to be *Aphis laburni*.

In the Gambia, as in other countries, the groundnut crop suffers severely in certain seasons from the effects of Rosette disease, and late sown fields in severe cases give practically no yield at all. Although no insect has yet been proved to transmit the disease in the Gambia, it may be useful, at the present stage of the investigations on the behaviour of the disease there, to review the information accumulated from general observations, and from the more exact figures of small plot experiments; then to consider what experiments can be devised further to elucidate the problem, and what practical and economic changes in agricultural practice are possible for the African peasant to adopt, to reduce the incidence of disease.

Description of Virus Types.

Three distinct types, transmittable by grafting, have been noted. Of these "Chlorosis Rosette" is by far the most common; "Green Rosette" occurs in small groups only, and rather infrequently. Type No. 3, characterised by a curving of the stems, has not been named, and is apparently rare. The descriptions which follow are based on observations at Cape St. Mary in 1929 and at Wuli Station in 1930 and 1931. In addition, in the latter year, a Philippine White and Gambia plant were grown in boxes raised from the ground, to facilitate closer observation. The plants became infected by Rosette disease about one month after germination, and a daily record was kept of the progress of the disease and of the flowering and pegging at each node. A chart was made, recording the date when each leaf showed signs of disease, and the condition of the flowers, &c., each day.

Chlorosis Rosette.

This form usually appears first at the tip of a lateral branch; the young leaves are flaccid, and about two days later they show small light yellow patches. As these leaves mature, the remainder of each leaf shows a normal amount of chlorophyll, while the yellow patches also become green, but of a slightly paler shade than normal; this difference can only be seen on close inspection. The next pair of leaves, however, usually shows light yellow and pale green patches which do not turn green, and the remainder of the leaf assumes a darker green than usual. The more chlorotic patches there are on the leaves, the darker green the green areas become, and older leaves with no chlorosis also become darker green.

When the disease attacks a young Runner plant, after a few days all the growing points (including that of the upright) show the disease. When the disease appears on an older plant it spreads much more slowly, and is confined to one lateral for a considerable time. The upright seems to be the last to get the disease, but this statement is based on a few observations only. One plant which had all laterals affected, with the upright free from disease, was treated as follows:—All the laterals were severed near to the centre of the plant. New branches were formed on the upright and none showed disease. About three weeks later shoots appeared where the original laterals had been severed and almost immediately showed disease. These were in turn cut off, and in a further three weeks they again sprouted, showing chlorosis. Up to this point the upright showed no signs of disease.

The shape of the leaf is affected by the disease, becoming narrower and more pointed; after the plant has been affected for about two weeks, the new leaves developing are much smaller than usual, and crinkled. About four days after the first appearance of the disease, the petioles of leaves on affected parts are shorter than normal, and leaves developing later have progressively shorter petioles until they are almost sessile.

Very soon after the disease appears, the flowers emerging each day are flaccid, and when three weeks have elapsed, they are reduced in size, are sessile and fail to open. Two days after the disease shows itself, a red colouring matter is invariably seen in the calyx. With the Philippine White variety, however, which is apparently an Albino, this does not occur.

The new internodes which emerge after the appearance of the disease are progressively shorter until the leaflets from adjoining nodes are touching. When the plant has made several sub-branches (tertiaries) arising from the laterals, the diseased leaflets at the tip of the sub-branches appear like a number of tufts. When, however, the disease appears on a very young plant, the laterals are so stunted that the tufts are very close together, giving the whole plant a bunchy appearance. The stems of a diseased plant are usually thicker than normal.

Towards the end of the rain season in 1929 Rosette appeared at Cape St. Mary, on poor land; the diseased plants showed proliferation to a certain extent, sub-branches appeared at the nodes in place of flowers, and the number of

GROUNDNUT ROSETTE DISEASE IN THE GAMBIA.

No. 1 Sketch of normal Groundnut branch. A.H.

A.H.

No. 2 Typical case of Chlorosis Rosette.

GROUNDNUT ROSETTE DISEASE IN THE GAMBIA.

No. 3 Sketch of branch affected by Green Rosette.

No. 4 Rosette Type No. 3.

flowers was few. In 1931, at Wuli Station, on better ground than at Cape St. Mary, Rosette appeared earlier in the season and no proliferation occurred; the plants with Chlorosis Rosette bore many more flowers than normal plants, and flowering continued right up to harvesting time. Daily flowering records were taken of diseased and normal plants. Relatively few pegs were formed, however.

No case was noted of a plant becoming infected with Rosette before 14 days had elapsed from germination, but in Sierra Leone (5), plants have shown Rosette in one week from germination. When a Rosette branch is grafted on to a normal plant, three weeks always elapse before the appearance of the disease in the healthy plants. If a week is allowed for the graft to catch, this gives a minimum of 14 days, as above, for the development of the disease. The first signs of Rosette always appeared on the branch bearing the graft. In the 11 cases observed, the disease spread to the other laterals before attacking the upright. Grafts in the centre of a field took seven to ten days longer to transmit Rosette than plants on the edge of the field. The plants were not caged, but no other plants in the vicinity became infected with Rosette. In the F2 generation of a groundnut cross (Valencia × Sine), all plants were grafted with Rosette branches to see if any segregates were immune. The amount of anthocyanin in the stems had been previously noted, and where plants were badly infected by Rosette, it was noticed that the red colouration of the stems was much reduced.

A peculiarity that has often been noticed (6) is that of two seedlings springing from a single shell, one may have Rosette and the other may be healthy. Six groundnuts in shell were planted in the position in which they would naturally occur, and it was found that the seeds did not germinate simultaneously, but that in every case the seed farthest away from the plant germinated first, the other following several days later. Thus insects might infect the first seedling and leave the vicinity before the later one germinated.

From a description of Rosette disease in South Africa the symptoms there and in the Gambia appear to be the same.

Green Rosette.

This is so called because no chlorosis occurs and the leaves are darker in colour than in a normal plant.

This type was first observed in a field near Abaku (K. & F) in 1929, and then at Wuli Farm in 1930 and 1931. It was thought that instead of being due to a different type of virus, this might be due to the chlorosis virus attacking the plant, while in a different physiological condition. To get information on this point, two branches infected with Chlorosis and Green Rosette respectively were grafted on to different laterals of the same plant. Chlorosis Rosette appeared on the branch bearing the Chlorosis graft 21 days after grafting, and Green Rosette appeared one day later on the lateral bearing the Green Rosette graft. There is thus an indication that we are dealing with two distinct viruses.

The effect of Green Rosette is similar to that of Chlorosis Rosette in the following particulars: shortening of the petioles, flaccidity of flowers, shortening of the peduncle, red colouration of calyx, shortening of internodes, and thickening of stems. A daily chart was not recorded for this type, so that time taken to arrive at each stage cannot be given as for Chlorosis Rosette.

Green Rosette differs from Chlorosis Rosette in the following particulars: there is no chlorosis, the whole leaf being darker than normal, the leaves are shorter, but not narrower than usual, giving the leaf a roundish appearance. From the daily flower records it was found that, in contrast to plants affected by Chlorosis Rosette, Green Rosetted plants did not flower more than normally.

Rosette Type No. 3.

The leaves are normal in colour, but much smaller and thicker. Much thickening of the stem takes place, and each branch is curved in a clockwise direction. There was some evidence of proliferation.

A diseased branch of this type was grafted on to a healthy plant, and 31 days later the same type of disease was reproduced on the lateral bearing the graft. This then spread to the other branches in a similar manner to that of Chlorosis Rosette.

Only two plants of this type were noticed, but as the leaves are similar in colour to those of normal plants, it may easily have been overlooked. It was only noticed through carrying out detailed observations on a groundnut plot for another purpose.

Practical Considerations.

Experiments have shown that the Philippine Pink (Bunch) variety, when planted late and at a spacing suitable for its bunching habit, is less liable to disease than Runners. This variety should therefore be retained for the later plantings. Seed of this variety has been widely distributed in the Gambia during the last few years, but it has often been noticed that the farmer plants it as a mixture with the Runner groundnuts (at the wider spacing suitable for the latter). This practice is worse than having no Bunch at all, as apart from a reduction in yield, the Bunch matures more quickly than the Runner with which it is mixed, and causes trouble in harvesting. The seed is distinctive and can be picked out when shelling, or better, the Bunch variety should be harvested separately and stored for late planting in pure stands.

Disease is affected to some extent by soil, but precise information is lacking. It appears that old land that has been subjected to continuous cultivation is particularly liable to disease, and this has also been found in Sierra Leone (2) and Tanganyika (12). At Wuli Experimental Station

in 1931, as has been noted in Nigeria (1), there were significant increases of Rosette on lower heavier land of less fertility, whereas groundnuts on good sandy soil were comparatively free. This may be a seasonal effect, caused by the rapid drying and cracking of the heavier soil during the exceptionally light rain season, since in 1927, in a season of higher rainfall, exactly the reverse happened. The soil effect may also be one of lack of fertility, so that the less vigorous growth does not allow the plants to meet quickly, giving a similar effect to that of late planting and wide spacing, the significance of which is noted later. Soil samples have been submitted to the Imperial Institute for the investigation of these points.

If the farmer's local knowledge leads him to believe that certain land is particularly subject to Rosette, such land should be put under groundnuts as early as possible in the season, if groundnuts must be planted there.

Observations and experiments have established the following points (13) :—

(1) Late plantings are more susceptible to Rosette than early plantings. (Variety and Planting Date Trial, Cape St. Mary 1930 and Wuli 1931, also general observations in the Protectorate from 1924).

(2) Wide spacing gives more disease than close planting. (Variety and Spacing Trials, Cape St. Mary 1930 and Wuli 1931).

(3) Disease appears to be associated with periods of drought. (General observations).

(4) Outside plants are more liable to Rosette than those in the middle of a plot. (Wuli 1931).

A well known native axiom is to defer weeding as far as can be done without seriously affecting yield, when disease is prevalent. An experiment was designed to determine whether this practice was sound, as far as the reduction of disease is concerned.

Object—(*a*) to find out if the native practice of leaving groundnuts weedy has any effect on the incidence of Rosette disease. (*b*) to confirm previous conclusions that close planting tends to inhibit Rosette.

The experiment was designed to settle these two points as definitely as possible, without regard to yield; therefore extremes of close and wide spacings were adopted, and the weedy plots were left as full of weeds as possible. In any case, the experiment was commenced too late in the season to enable the groundnuts to mature.

Summary of Results.

Variates, 6″ × 6″ clean.
6″ × 6″ weedy.
36″ × 36″ clean.
36″ × 36″ weedy.
Variety :—Basse.
Size of plots, 15′ × 18′.
Arrangement, Latin Square.
Date planted, 14th September, 1931.

Number of Plants per cent. infected with Rosette, 26th October, 1931.

6″ × 6″ clean.	6″ × 6″ weedy.	36″ × 36″ clean.	36″ × 36″ weedy.
48	11	73	nil.

$Z > 1\ \%$ S.E. = 3.17.

Conclusions.

The presence of weeds definitely tends to inhibit Rosette.

With the clean plots, wide spacing showed more Rosette than close spacing.

With the weedy plots, the wide spacing had no disease whatever, while the close spacing had a certain amount. This apparent contradiction was caused by the fact that the wide spacing was much more weedy than the close spacing. The method employed to ensure a good and regular stand of weeds was to select for the experiment a piece of weedy ground, and to hoe a thin line for each row of groundnuts; with the narrow spacing, as there was only a distance of 6″ between the lines, a much higher proportion of ground was hoed than for the wide spacing. Further, in the wide plots a very suitable grass (*Pennisetum setosum*) for the retention of moisture was dominant, whereas in the close spacings, owing to the different hoeing treatment, a thin straggly couch grass (*Digitaria marginata*) was more evident.

It will be noticed that all these measures have one thing in common, the provision of extra vegetative cover over the ground. Late plantings have not had time to cover the ground at the time that the disease is incident; weeds tend to prevent evaporation from the soil and induce dew formation. It thus appears that either soil moisture or atmospheric moisture around the plant is an important factor. Whether this affects the habit of the insect vector or the physiology of the plant is not yet known, but even without this knowledge, it is a profitable line of investigation to consider what alterations in agricultural conditions will effect a change in these factors (which are interdependent), and various possibilities are now considered. The danger of increased humidity favouring the development of Root Rot, Leaf Rust or Leaf Spot is not considered great under Gambian conditions.

Possible Lines of Attack.

(1) *Delayed Weeding.*

The farmer knows this already, and no good purpose can be served by advising this (which might encourage indolence) until the following points have been determined by exact experiment, with costs :—

(*a*) What reduction of crop may be expected by delaying weeding, and what additional return will the farmer obtain for other work that he may do during the time he would normally be weeding?

It should be noted that with late plantings, (which are the more liable to disease) weeding would take place during August, when the labour demands of most of the crops that are grown at present are lessening. There is no value in freeing the farmer's time if he has no other work to attend to.

(*b*) At what point is the reduction of Rosette balanced by reduction of yield due to weeds?

(2) *Selective Weeding.*

Pennisetum setosum appears to be the most suitable grass to leave, as it does not interfere much with the crop. Couch grass prevents the spreading of the vine and its habit does not render it suitable for the purpose in hand. There are many other weeds to be considered, but these two are by far the most common throughout the Gambia. The *Pennisetum* is more common on land which has been cultivated the previous year, but which is reasonably fertile. Such land could therefore be reserved for late plantings. The following points need to be determined before making recommendations.

(*a*) What is the additional amount of labour (if any) to weed selectively?

(*b*) How does the yield in this method compare with delayed weeding and clean weeding?

(3) *Encouragement of growth of a moderate amount of bush.*

This would help to retain atmospheric humidity. Instead of cutting down all bush and covering the stumps with soil (which delays sprouting), a reasonable amount could be left. The loss of area would be slight, and in any case farming will be extensive for many years to come.

(4) *Conservation of trees.*

A number of trees left singly on the farms should tend to retain humidity. The native practice, when clearing wooded parts for farming, is to ring and burn all trees that can be killed by this treatment. Unfortunately it is the best timber trees (Rosewood, Ironwood, Mahogany), some of which do not give such a dense shade as to prevent cultivation near to them, which are selected for killing; comparatively worthless trees, such as *Terminalia, Bombax,* Fig trees, &c., are left to increase as they are difficult to kill. From a forestry point of view alone, this practice is worth further investigation.

(5) *Interplanting.*

The usual practice is to select early planted groundnuts for interplanting with cereals, and such groundnuts are already less liable to Rosette. Interplanting through late groundnuts should help to prevent disease. It would be too late in the season to plant Gambian millets at this time, but imported, quick maturing cereals or small millets (*Eleusine, Panicums, Setaria*) could be grown.

Pigeon Pea could be used to define boundaries, &c., and so help to prevent the incursion of drying winds, provided that the farmer's attention is not thereby distracted from planting up whole areas of land requiring fallowing.

Cassava is often interplanted with early sown and self sown groundnuts. It could be planted, as usual, early in the rains and the land reserved for late plantings of groundnuts. A reasonable space should be left round each cassava plant to prevent damage by ploughing and lifting.

(6) *Strips of fallow through groundnuts.*

This could form the subject of experiment. If pressure on land was at all great the fallow strips could be made equal in width to those of the groundnuts, and the fallow and groundnuts interchanged the following year.

(7) *Planting Distance.*

Results of experiments to date show that closer planting than is normal in native practice increases yield. If this is confirmed by later experiments, then there will be a twofold advantage in planting closer, as it will tend to reduce disease also. This can be adopted by the Jollofs and some of the Fulas without any other difficulty than the reservation of sufficient seed, as they plant on the flat.

The experiments with seed from 1, 2 and 3 kernelled nuts may show that seed usually rejected for sowing is in fact suitable and this would help to provide more seed. The Mandingoes and some Fulas plough the land, and with the high grass that is present when the ground is prepared for late groundnuts, it is hardly possible to make the ridges less than 24 to 30 inches apart (from crest to crest). Some method must therefore be devised to overcome this wide distance between lines. Planting closer on the ridge may help to a certain extent, but the most promising subject for experiment is the sowing of two lines of groundnuts per ridge; by making the ridge the full 30 inches, leaving a broad flat top, and by planting the two lines near each edge of the top, there would be sufficient room for each to develop and the distance between rows of groundnuts would be halved, or nearly so.

(8) *Rogueing of first diseased plants to appear.*

This is the usual recommendation with many diseases, but there is not yet proof that it has any effect in checking the disease. There are strong indications, as noted previously, that the plant does not show signs of Rosette until at least 14 days after infection. During this period, the disease may possibly be transmitted, so that when the plants show signs of disease it may be too late to rogue. As it is quite foreign to the farmer's instincts to pull up plants while there is the slightest hope of obtaining anything from them, more should be found out about the transmission of the disease and the life history of the insect vector, before extending propaganda in this direction.

The increasing attention now being devoted to Rosette disease should result in additional information being available each year from the countries concerned. At present, it is not certain that the diseases mentioned are identical. The detailed descriptions of the various types of Rosette in the Gambia given above, may help

to establish the identity of the Rosette, Bunchy disease, Yellowing disease, Clump disease, Krauselkrankheit and Krulsickte of other countries, and so enable better advantage to be taken of information published by other workers.

For example, late sowings have been found to be more susceptible than early sowings to the attack of some type of virus disease in Madagascar (9), Nigeria (10), Sierra Leone (2) and South Africa (4). The disease has been associated with drought in Madagascar (9), with irrigation in Mysore (11), while in South Africa (4) farmers associate it with both excessive rain and drought; in Tanganyika (12) comment is made on the great influence of season on the disease. These statements agree with the seasonal differences at Wuli Experimental Station, mentioned previously. In addition to the Gambia, it has been noted in Uganda (3) that close planting tends to check the disease. Other references are noted under "Practical Considerations".

Summary.

(1) The increasing importance of Rosette disease is noted.

(2) A detailed description is given of three types of Rosette disease observed in the Gambia.

(3) The information obtained on the behaviour of the disease in the Gambia is summarised.

(4) An alteration in agricultural conditions is shown to reduce the incidence of the disease, and various methods of carrying this into practice are discussed.

(5) Reference is made to information obtained in other countries; it is pointed out that such information would be of greater value if it were certain that all the diseases quoted are identical.

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MOSQUITOES.

Transmission of Infected Mosquitoes by Aeroplanes.

Planes from the tropics will probably carry on their sides, along with the fire extinguishers, spray guns for killing insects. This innovation is to be expected as a result of studies of mosquito transportation by aeroplanes, which were carried out by Dr. T. H. D. Griffitts and J. J. Griffitts, of the United States Public Health Service. These investigators put stained mosquitoes on to planes leaving San Juan, Porto Rico, and recovered a certain number when the plane arrived at Miami, 1,250 miles away, that same day. "With conditions at airports such as would permit of many mosquitoes getting aboard, it might be expected that approximately one fifth of the original number would be transported for a long distance—at least 1,250 miles—in one day with repeated landing and opening of doors, hatches and windows, and refueling, unloading and loading taking place."

Under normal average conditions about airports, heavy infestation of aeroplanes would not be likely, but even one infected or infective mosquito of the yellow fever type might be the means of starting an epidemic. Considering, however, the small number carried by aircraft and the facility with which planes may be freed from mosquitoes, it is concluded that while the danger exists, aeroplanes can be efficiently treated so as to destroy mosquitoes and thus retardation of air traffic progress can be avoided.

The investigations were made with the co-operation of the Pan American Airways system on the three types of planes—Fokker tri-motor cabin planes; Sikorsky amphibian passenger planes, and Commodore cabin planes—operating between the West Indies, the western coast of South America, Central America, Panama, Mexico, Jamaica and Miami, Florida. — (*Science*, Vol. LXXIV, No. 1925.)

MANURIAL EXPERIMENTS.

With reference to the fourth paper on manurial experiments entitled "A Comparison of the Effect of a Complete Inorganic Manure, and Single, Double and Triple Doses of Pen Manure on the Yield of Plant and First Ratoon Uba Canes", published in the February issue of this Journal, the sentence on page 49 beginning "Its most expensive component is 10 cwt. of rock phosphate which could be replaced by 1 cwt. of superphosphate, or at the most 2 cwt." was intended to mean "*Its most expensive component is 10 cwt. of rock phosphate which could be reduced to a quantity of rock phosphate equivalent to 1 cwt., or at the most, 2 cwt. of superphosphate.*

P.E.T. & J.A.P.

THE RELATIONSHIP BETWEEN DEGREE BRIX (HYDROMETER) AND DEGREE BRIX (REFRACTOMETER) IN FINAL MOLASSES.

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I.—Introduction.

DENSITY measurements in the sugar industry are based on the Brix hydrometer. This instrument measures directly the per cent. sucrose by weight present in a pure aqueous solution. Hence, when used in impure sucrose solutions, all solids present are expressed in terms of this substance. If the non-sucrose solids are chiefly sugars, the difference between the true and apparent result is very small, but if the non-sucrose solids are chiefly non-sugars, then this discrepancy becomes relatively large. An example of the second case is Final Molasses, and, hence, in order to obtain a better estimate of the solids present, either (1) a more accurate method must be used, or (2) the relationship between the hydrometer reading and the result of a more accurate method must be known. The other methods of measuring the solids in solution are (1) by Pycnometer, (2) by Mohr's Balance, (3) by Drying and (4) by Refractometer. Of these, the first and second are seldom used. The method of estimating the solids by drying involves the use of a low temperature vacuum oven so as to avoid decomposition of fructose. The process occupies about four hours, and is therefore not often used for routine work. By far the most rapid and accurate method is by means of the refractometer, and instruments may now be obtained standardized for use in the tropics, and graduated both in refractive indices and per cent. sucrose. Many attempts have been made to determine the relationship between Degree Brix (by hydrometer) and one of the more accurate methods, since a true estimate of the total solids in molasses is of practical importance for stock-taking, &c. These attempts have resulted in the evolution of a series of formulae. In the present investigation, the relationship between Degree Brix (Hydrometer) and Degree Brix (Refractometer) has been studied from the statistical point of view, the estimates of solids by the two methods, in the same series of samples, have been correlated and regression coefficients calculated. The same statistical method was employed in calculating these results as was used in a previous paper (1). While it is obvious that the two results must bear some general relationship to each other, and hence a significant correlation coefficient is assured, the regression equation enables one variant to be calculated from the other, together with the standard deviation.

2. Review of the Literature.

Breyman (2) first suggested that, in calculating the true dry substance from the Degree Brix, the apparent non-sugar content (°Brix—per cent. Sucrose) should be multiplied by a factor, and the result added to the sucrose content. This constituted an attempt to determine the relationship between the non-sucrose content and sucrose. The factor used had to be determined separately for each factory. Sach and Weisberg (3) also made use of these coefficients. Muller (4) and Parr (5) have both suggested the use of a formula in which the basic assumption, in both cases, is that the difference between apparent and true dry substance per unit of non-sugar is constant. Thieme (6) has developed this idea and has set forth methods for calculating the true from the apparent values. The results of these calculations are factors which must be determined separately for each class of product in each factory and, depending on the accuracy desired, at fairly frequent intervals. The fluctuations are smallest, the lower the purity of the product. King (7) has suggested that carbonated ash determinations be used in conjuction with hydrometer solids for the determination of total solids, but a determination of carbonated ash is said to take five hours and the relationships only indicate a general tendency.

3. Experimental.

The samples of final molasses used in this investigation were composited weekly in three factories, Factory A for the crops 1929, 1930 and 1931, Factory B for the crop 1930, and Factory C for the crop 1931. Each sample was examined, amongst other determinations, for °Brix (Hydrometer), °Brix (Refractometer) and Total Solids by drying. The °Brix (Hydrometer) was determined by the method of half dilution, using spindles graduated at 84 °F. The refractometer was supplied by Zeiss and is graduated at 28 °C., the scale reading refractive indices and per cent. sucrose. The Total Solids by drying were determined by the method set out in Browne (8), a vacuum oven being employed. The results of these determinations were examined statistically.

4. Statistical.

It is evident that there should be a general relationship between the results of determining the solids by the three methods set out above. The hydrometer method usually yields the highest result, and there is a statistically significant difference between the mean of the results by this method and the mean of the results by the other two methods. The means of the other two methods are not, however, statistically different. The results of these tests are set out in Tables 1 (*a*), 1 (*b*) and 1 (*c*).

Table 1 (a).

FACTORY A. FINAL MOLASSES.

Method.	Mean.	D.F.	S.D.	Variance.	t =	
1. By Hydrometer	84.74	47	2.18	4.7496	(1)–(2)	10.22
2. By Refractometer	80.12	47	2.14	4.5734	(1)–(3)	11.20
3. By Drying	79.74	47	3.24	10.5220	(2)–(3)	0.68

Table 1 (b).

FACTORY B. FINAL MOLASSES.

1. By Hydrometer	84.97	13	1.32	1.75	(1)–(2)	8.4
2. By Refractometer	80.93	13	1.20	1.44	(2)–(3)	0.59
3. By Drying	80.61	13	1.66	2.76		

Table 1 (c).

FACTORY C. FINAL MOLASSES.

1. By Hydrometer	83.8	12	2.13	4.55	(1)–(2)	5.6
2. By Refractometer	79.7	12	1.53	2.33	(2)–(3)	0.36
3. By Drying	79.4	12	2.45	6.05		

Since the refractometer method is easier to manipulate and more rapid than the drying method, the correlations and regression coefficients were calculated for °Brix (Hydrometer) and °Brix (Refractometer) only. Two sets of calculations were made for each of the series of samples. The first, or "Direct Correlation", showed the relationship between °Brix (Hydrometer) and °Brix (Refractometer). The regression equations for these correlations, therefore, enable the °Brix (Refractometer) to be calculated direct from the °Brix (Hydrometer). The results are set out in Table 2.

The second, or "Non-sugar Correlation", showed the relationships between (°Brix (Hydrometer)—per cent. Total Sugars) and (°Brix (Refractometer)—per cent. Total Sugars) that is, between the hydrometer and refractive non-sugars. In order to obtain an estimate of the °Brix (Refractometer) from °Brix (Hydrometer), it is therefore necessary to add the result obtained from the regression equation to the per cent. Total Sugars. The basic assumption is, that since both the hydrometer and the refractometer are based on sucrose, one unit of sugar (sucrose or reducing sugars) will influence each of the instruments to the same extent. The results are set out in Table 3.

Of these two sets of correlations, the first or "Direct Correlation" is the simplest from the routine control point of view, because the hydrometer reading is all that is necessary in order to calculate the °Brix (Refractometer) from the formula. The "Non-Sugar Correlation" demands not only the hydrometer reading, but also an estimate of the reducing sugars and sucrose. The relative values of the regression equations obtained from each of the correlations may be seen by inspection of Tables 4, 5 and 6, where the predicted °Brix (Refractometer) is set out against the actual °Brix (Refractometer), together with the error introduced by the use of the former.

Figure 1 shows the regression lines for the "Direct Correlation" between °Brix (Hydrometer) and °Brix (Refractometer) for each of the factories, calculated on the basis of the formulae set out in Table 2. Similarly, Figure 2 shows the regression lines for the "Non-Sugar Correlation" for each of the factories, calculated from the formulae set out in Table 3. It will be noticed that the relative positions of the three lines is the same in both diagrams.

Table 2.

	No. Pairs.	Regression Coef.	° Brix (Refractometer) =
Factory A	48	+0.9188 ±0.034	2.3+(0.9188 x Hyd. Brix)
Factory B	14	+0.8979 ±0.040	4.6+(0.8979 x Hyd. Brix)
Factory C	13	+0.6965 ±0.070	21.3+(0.6965 x Hyd. Brix)

Table 3.

	No. Pairs.	Regression Coef.	°Brix (Refractometer) = % Total Sug. +
Factory A	48	+0.8873 ±0.03	(0.8873 x Hyd. non-sug.)—1.4
Factory B	14	+0.9412 ±0.09	(0.9412 x Hyd. non-sug.)—2.3
Factory C	13	+0.7275 ±0.10	2.5+(0.7275 x Hyd. non-sug.)

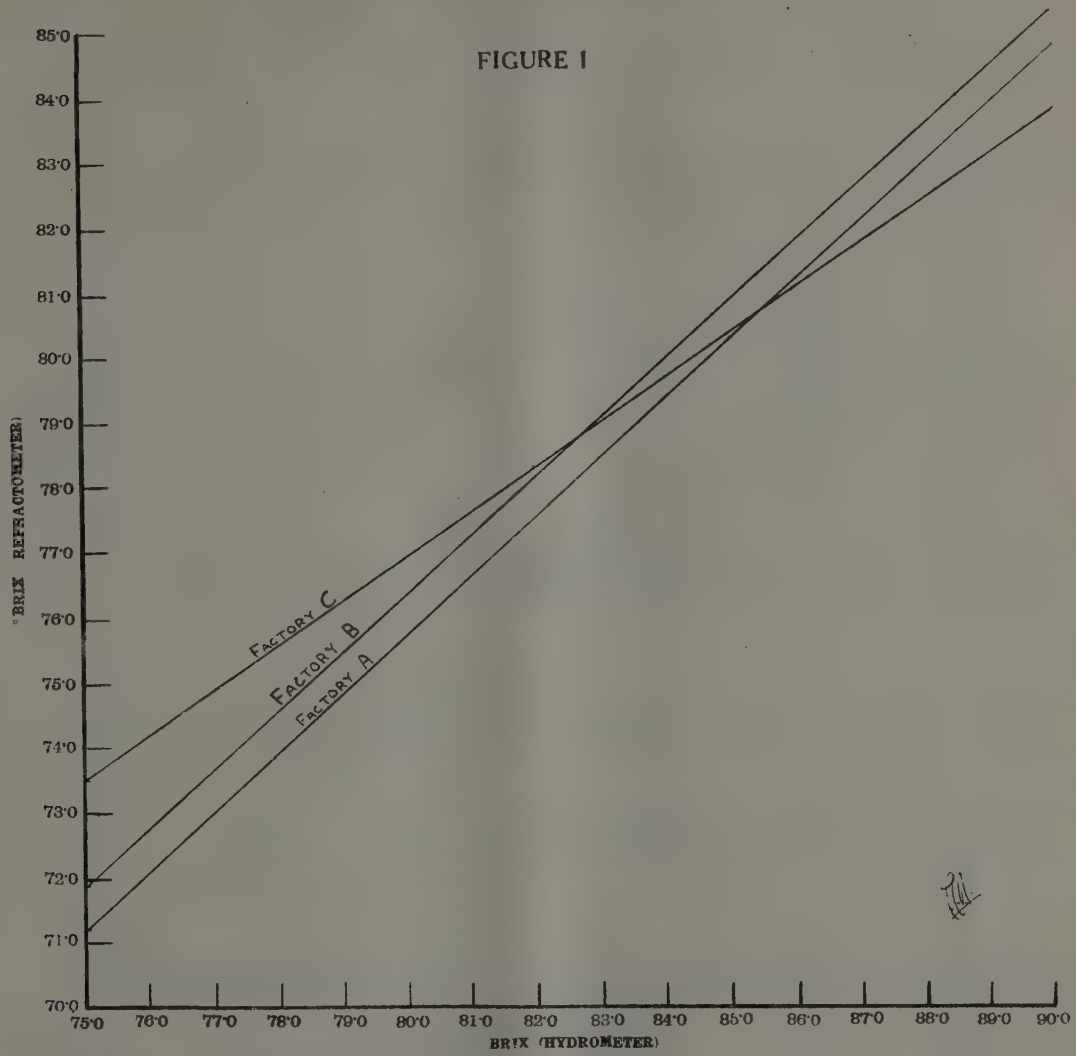
Table 4.

FACTORY A.—DIFFERENCE BETWEEN PREDICTED AND ACTUAL °BRIX (REFRACTOMETER).

ACTUAL °BRIX.		PREDICTED °BRIX (REFR.)		DIFFERENCE BETWEEN	
Hydrometer.	Refractometer.	From Direct Correlation.	From Non-Sug. Correlation	2 and 3	2 and 4
1	2	3	4	5	6
84.2	79.2	79.7	79.3	+0.5	+0.1
86.4	81.5	81.7	81.3	+0.2	−0.2
85.0	80.0	80.4	80.0	+0.4	0.0
86.1	81.2	81.4	81.0	+0.2	−0.2
86.8	81.7	82.1	82.0	+0.4	+0.3
84.2	79.2	79.7	79.4	+0.5	+0.2
84.1	79.8	79.6	79.5	−0.2	−0.3
85.7	81.6	81.0	81.1	−0.6	−0.5
85.3	81.0	80.7	79.8	−0.3	−0.2
84.3	80.1	79.8	79.5	−0.3	−0.6
81.3	76.7	77.0	76.4	+0.3	−0.3
82.0	77.3	77.6	77.0	+0.3	−0.3
82.3	77.7	77.9	77.6	+0.2	−0.1
81.1	76.0	76.8	76.3	+0.8	+0.3
80.2	76.1	76.0	75.4	−0.1	−0.7
79.2	74.6	75.1	74.7	+0.5	+0.1
79.3	74.2	75.2	74.2	+1.0	0.0
84.6	80.0	80.0	79.3	0.0	−0.7
85.1	80.0	80.5	79.7	+0.5	−0.3
82.4	77.4	78.0	77.1	+0.6	−0.3
84.1	78.7	79.6	78.6	+0.9	−0.1
84.1	79.0	79.6	79.0	+0.6	0.0
84.8	80.0	80.2	79.6	+0.2	−0.4
85.6	81.0	80.9	80.6	−0.1	−0.4
85.7	81.0	81.0	80.8	0.0	−0.2
85.5	80.9	80.9	80.6	0.0	−0.3
86.0	81.0	81.3	80.9	+0.3	+0.8
84.8	80.0	80.2	79.8	+0.2	−0.2
85.4	80.6	80.8	80.4	+0.2	−0.2
86.1	81.2	80.4	81.0	−0.8	−0.2
85.4	80.4	80.8	80.2	+0.4	−0.2
86.4	81.3	81.7	82.4	+0.4	+1.1
83.0	78.4	78.6	77.8	+0.2	−0.6
90.0	84.6	85.0	84.4	+0.4	−0.2
86.9	82.2	82.1	82.1	−0.1	−0.1
86.3	81.3	81.6	81.6	+0.3	+0.3
86.9	82.2	82.1	82.3	−0.1	+0.1
87.8	82.7	83.0	83.0	+0.3	+0.3
85.3	81.0	80.7	80.7	−0.3	−0.3
86.1	81.9	81.4	81.6	−0.5	−0.3
86.9	82.2	82.1	82.0	−0.1	−0.2
85.2	80.6	80.6	80.5	0.0	−0.1
86.8	81.6	82.1	81.8	+0.5	+0.2
87.3	81.8	82.5	82.1	+0.7	+0.3
88.7	82.8	83.8	83.5	+1.0	+0.7
87.4	82.2	82.6	82.3	+0.4	+0.1
84.0	79.4	79.5	79.2	+0.1	−0.2
85.2	80.8	80.6	80.3	−0.2	−0.5

By Direct Correlation, °Brix (Refractometer) = 2.3 + (0.9188 x Hyd. Brix).
By Non-Sugar Correlation, °Brix (Refractometer) = Per cent. Total Sugars + ((0.8873 x Hyd. non-sug.) − 1.4).

FIGURE 1



5. Discussion.

The use of a regression equation to calculate °Brix (Refractometer) from the °Brix (Hydrometer) appears to yield accurate results. The magnitude of the difference between the predicted result and the actual result may be gauged by inspection of Tables 4, 5 and 6. The following example, which demonstrates the importance of an accurate estimate of the solids in final molasses, is based on data from Table 4:

Final Molasses:

From Table:
°Brix (Hydrometer) 85.1.
°Brix (Refractometer) 80.0.
Predicted °Brix (Refr.) 80.5.

Assume:
1,000 cu. ft. product.
30.0 Purity.

	From Hydr.	Difference.	*From Refr.*	Difference.	*From Predicted Ref.*
Wt. 1,000 cu. ft. Molasses	90,340 lb.	2160	88,180 lb.	210	88,380 lb.
Wt. Solids in 1,000 cu. ft.	76,880	6340	70,540	610	71,150
Wt. Sucrose in 1,000 cu. ft.	23,064	1719	21,345	183	21,162

Table 5.

FACTORY B.—DIFFERENCE BETWEEN PREDICTED AND ACTUAL °BRIX (REFRACTOMETER).

ACTUAL °BRIX		PREDICTED °BRIX (REFR.)		DIFFERENCE BETWEEN	
Hydrometer.	Refractometer.	From Direct Correlation.	From Non-Sug. Correlation.	2 and 3	2 and 4
1	2	3	4	5	6
87.9	83.6	83.5	83.9	−0.1	+0.3
85.7	82.0	81.6	81.1	−0.4	−0.9
84.7	80.8	80.6	80.7	−0.2	−0.1
84.1	80.3	80.1	80.2	−0.2	−0.1
86.1	82.0	81.9	81.1	−0.1	−0.9
86.0	81.7	81.8	82.0	+0.1	+0.3
86.3	82.0	82.1	82.3	+0.1	+0.3
84.2	80.4	80.2	80.2	−0.2	−0.2
82.9	79.2	79.0	78.8	−0.2	−0.4
84.2	80.1	80.2	80.2	+0.1	+0.1
83.1	79.1	79.2	79.1	+0.1	0.0
84.3	80.2	80.3	80.3	+0.1	+0.1
84.3	80.2	80.3	80.3	+0.1	+0.1
85.7	81.4	81.6	81.7	+0.2	+0.3

By Direct Correlation, °Brix (Refractometer) = 4.6 + (0.8979 x Hyd. Brix).

By Non-Sugar Correlation, °Brix (Refractometer) = Per cent. Total Sugars + (0.9412 x Hyd. non-sug.) − 2.3.

Table 6.

FACTORY C.—DIFFERENCE BETWEEN PREDICTED AND ACTUAL °BRIX (REFRACTOMETER).

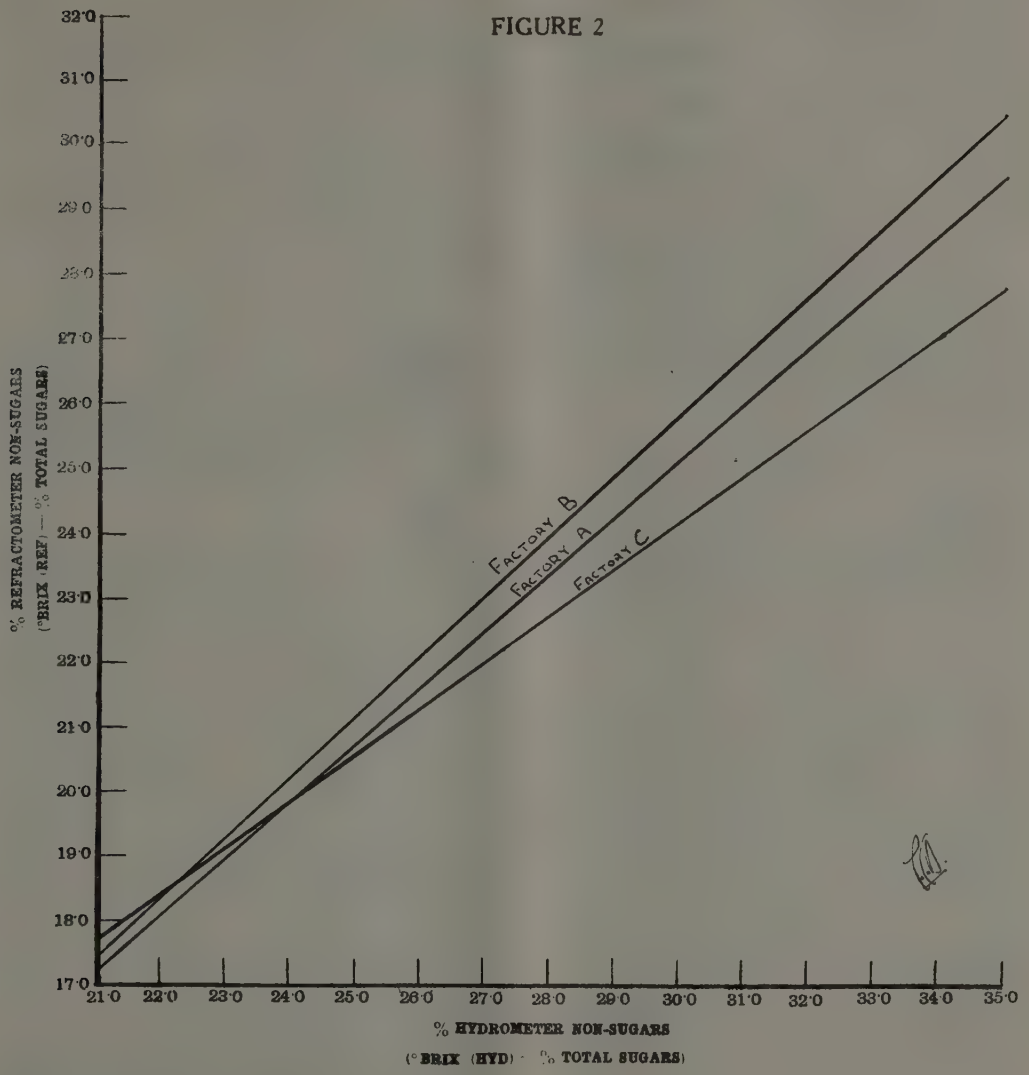
ACTUAL °BRIX.		PREDICTED °BRIX (REFR.)		DIFFERENCE BETWEEN	
Hydrometer.	Refractometer.	From Direct Correlation.	From Non-Sug. Correlation.	2 and 3	2 and 4
1	2	3	4	5	6
83.3	79.2	79.3	79.7	+0.1	+0.5
84.6	80.4	80.2	81.1	−0.2	+0.7
82.1	78.0	78.5	78.4	+0.5	+0.4
85.3	80.9	80.7	81.2	−0.2	+0.3
82.1	78.8	78.5	78.7	−0.3	−0.1
84.6	79.4	80.2	79.7	+0.8	+0.3
83.1	79.4	79.2	78.5	−0.2	−0.9
78.2	76.0	75.8	74.8	−0.2	−1.2
85.2	81.1	80.6	81.3	+0.5	+0.2
83.2	78.9	79.2	78.9	+0.3	0.0
86.2	81.4	81.3	81.5	−0.1	+0.1
86.8	81.8	81.8	81.9	0.0	+0.1
84.6	80.5	80.2	80.3	−0.3	−0.2

By Direct Correlation, °Brix (Refractometer) = 21.3 + (0.6965 x Hyd. B.)

By Non-Sugar Correlation, °Brix (Refractometer) = Per cent. Total Sugars + (2.5 + (0.7275 x Hyd. non-sug.))

Taking the °Brix (Refractometer) as a standard for comparison, it will be seen that considerable errors are introduced when the weights are calculated from the value "Weight of 1 cu. ft." at the °Brix (Hydrometer). These errors are, however, considerably reduced when the predicted °Brix (Refractometer) is employed. In terms of sucrose, the discrepancy is 8.0 per cent. too high when the hydrometer reading is used, and but 0.8 per cent. too low when the predicted refractometer reading is used. The use of the refractometer to obtain a better estimate of the °Brix of the molasses direct, or the use of a regression equation to obtain an estimate of this reading from the °Brix (Hydrometer) will therefore be an obvious advantage in taking stock for a sucrose balance, or in selling molasses by weight, when such stock is calculated from a volume measurement and density determination.

FIGURE 2



6. Summary.

1. The relationships between °Brix (Hydrometer), °Brix (Refractometer) and Total Solids (by drying) have been examined statistically.

2. There is a significant difference between °Brix (Hydrometer) and both °Brix (Refractometer) and Total Solids (by drying).

3. There is no significant difference between °Brix (Refractometer) and Total Solids (by drying).

4. Regression equations have been calculated from data from molasses of three factories showing the relationship between °Brix (Hydrometer) and °Brix (Refractometer).

5. The predicted °Brix (Refractometer) is, in nearly all cases, very close to the actual °Brix (Refractometer).

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WEST INDIAN NOTES.

Compiled by the Agricultural Advisory Department, Imperial College of Tropical Agriculture.

Cotton Conference at Barbados.

The Governor of Barbados invited the Conference to meet in Barbados, and made suitable arrangements for the representation of cotton growers from the various islands.

The Conference was opened by His Excellency on 31st March at Queen's House, and the business sessions were held daily from 4th to 7th April. The first and the final sessions were open to the public and the press, and accounts of those meetings appeared in the local newspapers. The Chairman throughout was the Commissioner of Agriculture.

DELEGATES.

Professor H. A. Ballou, M.SC.—*Commissioner of Agriculture.*

G. A. Jones, Esq.—*Assistant Commissioner of Agriculture and Official Representative of Antigua.*

S. C. Harland, Esq., D.SC.—*Cotton Adviser to the Commissioner of Agriculture.*

A. M. Reid, Esq.—*Official Representative of St. Kitts.*

R. C. Otway, Esq., O.B.E.—*Official Representative of Montserrat.*

The Hon. H. F. Shand.—*Representing the Montserrat Company.*

Chief Justice R. S. Thacker.—*Official Representative of St. Vincent.*

The Hon. A. Punnett.—*Official Representative of St. Vincent.*

The Hon. R. W. R. Miller, B.A.—*Official Representative of Barbados.*

The Hon. G. L. Pile, M.L.C.—*Official Representative of Barbados.*

W. K. Gooding, Esq.—*Official Representative of Barbados.*

T. W. B. O'Neal, Esq.—*Official Representative of Barbados.*

A. de L. Inniss, Esq.—*Official Representative of Barbados.*

L. T. Yearwood, Esq.—*Official Representative of Barbados.*

The Conference emphasized the lack of demand for Sea Island Cotton, and stressed the fact that there were large stocks of unsold cotton from the last two or three sessions, amounting to nearly 2¾ million pounds, or the equivalent of some 6,845 bales of 400 lb. The average production for the past ten years has been about 4,000 bales per annum. In addition to the unsold stocks, there is an unknown quantity of Sea Island Cotton which has been sold, but which has not yet been consumed.

The Conference recognised the need for heavy reduction in output, and for investigating possibilities of stimulating the consumption of Sea Island Cotton by developing new uses. Furthermore it recommended a special campaign for selling articles made of Sea Island Cotton, and provision for protecting the use of the name.

With the object of providing investigations, the Conference recommended that a West Indian Cotton Growers' Association be formed with a parent organization in the West Indies and a committee employing a specialist officer in the United Kingdom.

The Fruit and Vegetable Industry.

The tomato season has now ended, and the following approximate figures, showing the export in 20 lb. crates up to the end of April, indicate the bulk of the crop. Last year's figures are given for comparison:

From		1931	1932
Montserrat	....	17,000	18,400
St. Vincent	....	1,300	8,200
St. Kitt's	....	4,600	1,500
Nevis	....	1,300	1,400
Antigua	....	400	900

It is thus seen that this year's crop shows an increase of about 6,000 crates, largely due to the increased St. Vincent production, which more than balances the decrease in exports from St. Kitts.

It was hoped to obtain better prices following the peak of the Bahamas shipments in January February, but arrivals from the Bahamas continued to be fairly heavy, and, in the latter part of March and early April, the market was glutted with Mexican fruit. Thus 42 carloads apart from ten cars from the Bahamas, &c., arrived from Mexico on the Montreal market over a 20-day period, during which period the total demand was only about 20 carloads. Prices, therefore, naturally fell to low and unremunerative levels. Up to the time of writing, no account sales have been received indicating a market recovery. The situation has also been affected by the general economic depression and consequent low price levels, consumers tending to purchase canned instead of fresh products.

The situation might be improved somewhat by maintenance of the dump duty during the winter months, and this would appear to be a question which justifies consideration.

From general information obtained in Canada by Mr. A. C. Shill, the Marketing Officer, it appears that the grading and packing of tomatoes from the Leeward and Windward Islands during the past season have been uniform and satisfactory. The fruit from this region, however, tends to soften on attaining full colour; this is detrimental to satisfactory marketing. Apparently softening is not due to the cultivation of wrong varieties, but either to climatic conditions or to inadequate or incorrect manuring.

Observations of the condition of the fruit on arrival in Canada showing for example, an average of only five per cent. to 30 per cent. ripe fruits, indicate that cold storage of the tomatoes for periods of up to 13 days before shipment is not injurious. It has been found that the rise in temperature of fruit during transference from cold storages on shore to ships is usually only about 1° to 5°F., and special protection during transference does not seem to be warranted.

A few small shipments of tomatoes have recently been successfully made from Montserrat to New York.

As regards the export of beans, experience gained during this past season, when shipments were made to Canada at different temperatures, indicates that the transit period is too long to ensure arrival in sound condition.

Small shipments of other vegetables have been made to Canada and Bermuda with fair success. The possibility of expansion of onion production appears promising.

Dominica oranges and grapefruit gained a good reputation in the Maritimes last winter, according to opinions gathered by Mr. Shill in Canada. The orange sales were reasonably satisfactory despite a rather poor market, but the dumping of grapefruit, often at a loss, from Florida and other areas, made the market demand and price of this commodity unsatisfactory. It should be noted, however, that the citrus market in Canada during the past winter was one of the worst on record.

Small shipments of limes are now being made to Canada. This market should be encouraged but shipments in these early stages ought to be limited. From recent summer quotations for lemons there seems every possibility that limes will sell fairly well this summer in Canada.

Lime shipments to the United States of America are increasing with the main crop season now in progress. In one week in mid May, about 700 barrels were shipped from Dominica, and 450 from St. Lucia. The shippers should seriously consider the adoption of a shipping container more suited to retail distribution, for example, the 20 lb. tomato crate which is well received by the trade in Canada.

Shipments of common mangoes to Bermuda are in progress, the season having started in April. St. Lucia shipped 440 crates up to the end of April, and Dominica 250 crates up to 10th May.

At the time of writing (1st June) only small quantities of mature fruit of grafted mango varieties are available.

St. Lucia has recently shipped about 100 crates of Creole pineapples to various destinations, and St. Kitts is also expecting to have a surplus for export. The St. Lucia production, with recent importations of new stock, should increase within the next few years.

Miscellaneous.

Mr. H. A. Ballou, Commissioner of Agriculture, who attended the Cotton Conference at Barbados, left Trinidad on 21st March and returned on 10th April.

Mr. G. A. Jones, Assistant Commissioner of Agriculture, after a tour of the islands from 29th February to 30th April, including attendance at the Cotton Conference, returned to Trinidad on 30th April.

Mr. A. C. Shill paid a brief visit to Canada in connection with his work as Marketing Officer. A report on this visit will shortly be issued. Mr. Shill is proceeding to Tortola to investigate the prospects of a development in the Virgin Islands of a fruit and vegetable trade with outside markets.

Mr. E. A. Walters proceeded on leave from St. Lucia on 25th April. Mr. Walters is expected to be absent for 5½ months. Mr. A. F. Nichols will be acting Agricultural Superintendent during Mr. Walters' absence.

Dr. S. C. Harland, Geneticist, Cotton Research Station, Trinidad, and Cotton Adviser to the Commissioner of Agriculture, visited St. Vincent on 17th to 25th March to confer with Mr. S. H. Evelyn on the work of the past season, and to plan the work of the coming season. Dr. Harland visited Barbados on 31st March to 9th April as Delegate to the Cotton Conference.

Mr. S. H. Evelyn, Cotton Research Officer, arrived in Trinidad on 14th June to spend a few weeks at the Cotton Experiment Station, during the in-between of the cotton seasons in St. Vincent.

Mr. F. H. S. Warneford has interested himself in the revival of the Reading Courses and Examinations in Practical Agriculture in Antigua. Between 1908 and 1921 successful Reading Courses and Examinations were conducted by the Imperial Department of Agriculture. They were well patronised, and a high standard was maintained in each of the three grades. If a sufficient interest in this work is shown by estate overseers the Reading Courses and Examinations will be revived under the aegis of the Advisory Department of the College.

Planting material of eight varieties of sugar-cane has recently been sent from the College to the Agricultural Superintendent, St. Kitts. These canes have been planted in an isolated area, and will be kept under supervision for at least one season before being released for estate planting. A collection of six varieties of pigeon pea, received from the Department of Agriculture, Trinidad and Tobago, has been sent for trial by the Commissioner of Agriculture to Montserrat. On his recent visit to the West Indies, Mr. F. A. Stockdale suggested that more might be done in the cultivation of pigeon peas, and suggested that a red-seeded variety for the production of dhal might be useful for such markets as Trinidad and British Guiana.

Through the kindness of the Director of Agriculture, Nigeria, the Commissioner of Agriculture has received a small supply of seed of a tropical onion. These seeds are being distributed for trial. The main interest in this onion is that it is said to produce seed freely in the tropics. Onion seed for planting in the West Indies is generally obtained from Teneriffe, but there is a tendency for this seed to be received too late. By the time the seed has been ripened, cured, shipped and distributed in the West Indies, the best season for planting is usually past. A suitable onion which would provide an ample supply of seed each year would be of great value.

Dr. J. G. Myers has recently returned from Cuba where he has been collecting the Tachinid fly (*Lixophaga*) for shipment to Antigua and St. Kitts. The cost of Dr. Myers' trip was sustained by the sugar planters of those islands, and several consignments of the parasites have been received and liberated. Mr. H. E. Box, who received the consignments and attended to the liberation,

reports that the parasite has been recovered in cane-fields both in Antigua and St. Kitts, and that it may be taken that the introductions have been successful. Mr. Box visited St. Kitts where he liberated the first consignments of *Lixophaga* from Cuba, and arranged for Mr. Gregory to receive and liberate later lots. Dr. Myers and Mr. Box attended the International Congress of Sugar-Cane Technologists at Porto Rico in March. Dr. Myers also visited Jamaica and the Bahama Islands, and returned to Trinidad by air *via* Colombia and Venezuela.

The success of the chalcid parasite (*Eretmocerus serius*) of the Black Fly (*Aleurocanthus woglumi*) in Cuba has been so great that Dr. Myers took the opportunity of introducing the parasite into Jamaica where there would appear to be a good chance of its becoming established.

During his recent trip, Mr. Jones visited Anguilla. This is the first visit of an Agricutural Officer from the Advisory Department (Imperial Department) since Mr. Ballou's visit in 1921, soon after the appearance of pink bollworm in that island. Apparently pink bollworm continues to be a serious pest in Anguilla.

Mr. E. O. R. Lake, who has served as Agricultural Instructor for just over a year, appears to be doing good work. English potatoes of high quality have been grown but Mr. Lake in his recent quarterly report states that the yield is too low.

Mr. F. W. Urich visited St. Vincent in April in connection with studies of the Arrowroot Caterpillar (*Calpodes ethlius*) which is at times a serious pest of arrowroot.

Mr. K. T. Rae, Agricultural Superintendent, Grenada, has resigned his post. Mr. Rae came to Grenada from Nigeria about two years ago. It is understood that his retirement is due to continued ill health.

The Gyrotiller has now been demonstrated in Antigua and Trinidad. The work of this machine, appears to be excellent and the running costs moderate. The first cost of the machine, however, is considerable. The figures presented at a recent demonstration in Trinidad indicate that, even with the high initial cost, the efficiency of the machine and its low operating costs would eventually effect a saving in the costs of sugar production.

BERMUDA TOMATOES.

THE Director of Agriculture in a recent letter to us states that the Tomato Packing Shed which was described in the March issue of this Journal has been extended. It now measures 180 feet and is one, two and three storeys high as it proceeds down hill. A floor 60 feet long has been added and a Boggs Onion and Potato Grader has been installed. A similar floor is being used for Carrots while the Upper floor is being used for making and storing crates. A pamphlet included with the letter shows that exports of vegetables to Canada have risen from 7,973 bushels in 1931 to 30,430 bushels in 1932.

SUGAR NOTES.

Compiled by the College Department of Sugar Technology.

Cane Sugar as an Industrial Raw Material.

Intensive study is now being made of cane sugar as an industrial raw material. Drs. Gerald J. Cox and John Metschl, of the Mellon Institute of Industrial Research, Pittsburgh, Pa., reported the progress of some of their investigations at the meeting of the American Chemical Society at New Orleans on 29th March, 1932.

One of the substances that they have made from sugar, sucrose octoacetate, has been found valuable in certain types of lacquers and adhesives and in the fabrication of paper. A similar product, sucrose benzoate, has applications in the same fields. By treatment of sugar with acid at high temperatures, a substance called levulinic acid is produced, and when it in turn is combined with certain alcohols, fragrant esters are formed that have useful solvent powers.

But of greatest interest is their investigation of the practice of mixing sugar in lime-sand mortar. Controlled tests have shown that if as little sugar as six per cent. of the quicklime is included in mortar, the tensile strength is increased about 60 per cent. With the present low price of sugar, the addition of 5 lb. or 6 lb. of sugar for each 100 lb. of lime adds very little to the cost of laying bricks or plastering walls. The sugar is added dissolved in water after the lime has been slaked.—(*Chem. & Ind.*, Vol. LI., No. 14, 1932, p. 301.)

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Chemical Composition of Four Sugar Canes.

Representative stalks of four sugar cane varieties: Luzon White, Badila, Mauritius 1900 and Negros Purple, were cut into tops, bottoms and intermediate portions. These sections were separately analyzed and also the leaves.

It was found that when the canes are young there is a great difference in the sucrose contents of the tops and bottoms, but as the canes mature the amount of sucrose is fairly uniform in the different portions of a millable stalk. As the cane matures the differences in glucose content of the different portions of the stalk decrease.

A wide variation was found in the inorganic constituents of the four varieties analyzed. Silica constitutes the greatest portion of the sugar cane ash, particularly the ash of the leaves and leaf sheaths. With the exception of iron oxide all the other inorganic elements have a tendency to accumulate more in the growing point and in the leaves than in any other part of a sugar cane stalk.

As the cane becomes older the per cent. of sucrose tends to increase toward the top. The best time for harvesting the cane is when the per cent. of sucrose in the top approaches that of the bottom.—(*Facts About Sugar*, Vol. XXVI, No. 10.)

IMPERIAL COLLEGE OF TROPICAL AGRICULTURE

COLLEGE NEWS BULLETIN

JULY, 1932.] [No. 3.

COLLEGE NEWS.

Dr. J. R. Dickson, Medical and Health Officer, and Mrs. Dickson, sailed for England by the s.s. *Venezuela* on 31st May.

* * *

Mr. E. E. Cheesman, Professor of Botany and Genetics, sailed for England by the s.s. *Bayano* on 16th May on leave.

* * *

Mr. A. Pickles, Entomologist to the Sugar-Cane Investigation Committee, and Mrs. Pickles returned from England by the s.s. *Ariguani* on 3rd April.

* * *

Captain W. F. Watson, O.B.E., Attorney of Waterloo Estates, Ltd., has been nominated by His Excellency, the Governor of Trinidad and Tobago, as a Governor of the College in the vacancy caused by the resignation of Mr. E. A. Robinson.

* * *

Mr. F. Hardy, Professor of Agricultural Chemistry, and Mr. J. A. McDonald, of the Department of Soil Science, visited Antigua, Leeward Islands, during 24th March to 16th April, for the purpose of investigating sugar-cane soils, in connection with the work of the College Advisory Department.

* * *

We offer our heartiest congratulations to Mr. E. E. Pyke, Botanist to the Cacao Research Scheme, and Miss A. S. Jardine, who were married in St. Augustine on Thursday, 31st March; also to Mr. C. T. Watts, College Engineer, who was married to Miss Carmilla de la Bastide on Saturday, 30th April.

* * *

His Excellency, the Governor of Trinidad and Tobago, paid an official visit to the College on 31st May, and spent the whole day in company with the Principal. Sir Claud Hollis visited the various departments of the College and discussed recent developments in research with the various scientific officers concerned.

* * *

Mr. F. W. Urich, Assistant Professor of Entomology, will represent the Imperial College of Tropical Agriculture at the Fifth International Congress of Entomologists which is to be held in Paris from the 16th to the 23rd of July. Further information about this Congress may be obtained from the Secretary, Dr. R. Jeannel, 45 bis, Rue de Buffon, Paris (5 eme).

* * *

Among recent visitors to the College were:—Sir Edward Denham, K.C.M.G., Governor of British Guiana; Dr. O. Kaden, scientific officer to the San Thomé Planters' Association; Sir Hugo Fitz-Herbert; Major Edward E. Long; Professor D. Eduard Reidienow of the Institute of Tropical Diseases, Hamburg; Mr. C. W. Rayworth of Montreal; Dr. E. F. Scott of Columbia University, U.S.A.; and Mon. M. R. Guerard, a Director of the Compagnie Generale Transatlantique.

* * *

The following members of the Staff sailed for England on leave by the s.s. *Coronado* on 30th May:—Mr. J. G. Davies, Assistant Sugar Technologist; Mr. G. Gianetti, Editor-Librarian and Registrar, and Mrs. Gianetti; Mr. G. A. Jones, Assistant Commissioner of Agriculture, and Mrs. Jones; Mr. D. D. Paterson, Lecturer in Agriculture; Mr. E. E. Pyke, Botanist to the Cacao Research Scheme, and Mrs. Pyke; and Mr. P. E. Turner, Lecturer in Chemistry.

* * *

Mr. J. J. C. Buckley arrived from England by the s.s. *Ariguani* on 3rd April. Mr. Buckley, who is a member of the Staff of the London School of Hygiene and Tropical Medicine, will carry out some investigations at the College on Helminthology for a period of eight months. These investigations will be chiefly concerned with the internal parasites of domestic animals. He will study such problems as the relation of Necator of pigs to that in man; the life history of *Filaria ozzardi* and *Bilharzia mansoni*. Mr. Buckley expects to visit St. Vincent, Venezuela and St. Kitts during the course of his studies. If he has time, he may also look for eelworm infestation of economic plants.

SPORTS.

[*The Editor is indebted to the Captains of the College Clubs for the information which they supplied for the following retrospects.*]

Rugby Football Club, 1931-32.

Although six out of eight matches were lost, the Club improved steadily during the season and were, on the whole, perhaps a little unlucky to lose such a large proportion of the matches played. In view of the considerable improvement which has of late been shown in Trinidad Rugby, the College XV, as is shown by the scores, put up some creditable performances. Especially were these noticeable at the end of the season when some of the matches were very closely contested.

The XV, as in past years, is much indebted to the local clubs for their hospitality and for the enjoyable fixtures which they provided during the season.

The following represented the College :—

Full back, A. Garces; *Three-quarter backs*, A. E. Moss, J. de la Bastide, P. C. Chambers (*Captain*), G. R. J. Murray; *Halves*, B. C. G. Charles, E. J. Gregory; *Forwards*, B. R. Jones, J. T. H. Stein, A. R. Foster, J. R. E. Hindson, J. T. Moon, A. Jones, J. G. Davies, C. L. Willding-Jones, H. L. Manning.

The following also played for the College : J. J. Anderson, A. K. Briant, G. C. Stevenson, W. B. Mason.

MATCH RESULTS

Played 8 : *Won* 2 : *Lost* 6 : *Points for* 57 : *Against* 70.

Date.	*Opponents.*	*Results.*	
15th Oct.	Trinidad Northern	Lost	8-23
22nd Oct.	Caribbeans..	Lost	11-13
29th Oct.	Trinidad Northern	Lost	13-19
15th Nov.	Trinidad Southern	Won	5- 0
19th Nov.	Caribbeans..	Won	8- 0
29th Nov.	Trinidad Southern	Lost	9-10
12th Dec.	Trinidad Northern	Lost	3- 5

* * *

Association Football Club, 1931-32.

The Soccer Club had an enjoyable and fairly successful season. Leaseholds were twice beaten, each time by a narrow margin. One of the two matches with the Constabulary was won. It was unfortunate that Casuals had to be played for the Football Association Trophy early in the season before the side had settled down. A fixture was arranged against the officers of H.M.S. *Exeter* during the Navy visit. This game was particularly enjoyable and was won by the College.

The outstanding members of the team were G. C. Stevenson, who was very clever on the right wing, G. R. J. Murray and A. Jones. H. L. Manning and C. L. Willding-Jones also worked particularly hard.

The following represented the College :—J. M. McEwen, H. C. Miller, A. Jones, M. Barcant, B. R. Jones, H. L. Manning, C. L. Willding-Jones, G. C. Stevenson, P. C. Chambers, G. R. J. Murray, A. E. Moss (*Captain*), J. de la Bastide. J. A. Rudderham also played.

* * *

Water Polo Club, 1931-32.

The College has shown much keenness in swimming this year, and many members have visited the Pool on most evenings, with the result that the standard of swimming has increased considerably. Only a few members were familiar with the game of Water Polo at first, but after much practice throughout the season, quite a useful team was built up. Eight matches have been played, four of which were won. The first match, against Port-of-Spain, was lost by a narrow margin, but in a return match later in the season, the College won conclusively by four goals to two. The matches against the officers of H.M.S. *Exeter* and Pointe-à-Pierre were won comfortably, but H.M.S. *Hood*, which claims to have the strongest team in the Navy, proved too much for the College.

During the first visit of the Navy, a knockout Water Polo competition was organised at the Marine Club between ship's company teams from H.M.S. *Repulse*, H.M.S. *Exeter*, Port-of-Spain, and the College. In the first round the College beat H.M.S. *Exeter* 1-0, but lost to H.M.S. *Repulse* in the final. The same afternoon there was also a team race, the result of which was, H.M.S. *Repulse* first, Port-of-Spain second, I.C.T.A. third, H.M.S. *Exeter* fourth. The race was a close one.

Team :—J. R. E. Hindson, A. R. Foster, L. C. W. Greaves, H. L. Manning, P. C. Chambers, J. de la Bastide, A. Garces, G. R. J. Murray, J. A. Rudderham (*Captain*), J. G. Davies.

MATCH RESULTS.

Opponents.	*Results.*
Port-of-Spain	1-2
H.M.S. *Exeter* (Officers)	7-3
H.M.S. *Exeter* (Ship's Company)	1-0
H.M.S. *Repulse*	0-4
H.M.S. *Hood*	0-7
H.M.S. *Hood*	0-5
Pointe-à-Pierre	7-0
Port-of-Spain	4-2

Cricket Club, 1931-32.

Due to misunderstanding in the arranging of fixtures, few matches were played. In addition, cricket ability in the College this year was of a very low standard.

Three games were arranged with visiting warships, all of which proved most enjoyable. A keen finish resulted in the fixture with H.M.S. *Norfolk*, when, unfortunately, bad light and rain put an end to the play. Both matches with Queen's Park Cricket Club were lost. At the College, six of the visitors' wickets fell for 36 runs, but then M. Grell hit fiercely and included six sixes in his innings of 51. On a rainsoaked wicket at the Oval, the Queen's Park spin bowlers were altogether too good for the College batting.

In the annual game against the Staff, the Students scrambled home by 1 wicket. It was very unfortunate that the Principal was unable to lead his side owing to injury.

Mention must be made of B. Darwent, a promising all-rounder, of B. R. Jones, who bowled steadily, and of Mr. Corbin, who very generously gave up a good deal of his time to umpire for the Eleven.

Team:—A. R. Foster, B. R. Jones, B. Darwent, H. C. Miller, J. T. Stein, C. L. Willding-Jones, D. F. Ruston, H. L. Manning, J. M. McEwen, L. de Verteuil, and A. E. Moss (*Captain*). M. Barcant also played.

MATCH SUMMARY.

Versus H.M.S. *Repulse*. Drawn.
College: 132 for 5 wickets, declared (Darwent 41, Foster 34, Moss 32).
H.M.S. *Repulse*: 71 for 9 wickets (Darwent 5 for 24, Jones 3 for 14).
Versus H.M.S. *Hood*. Won by 9 wickets.
H.M.S. *Hood*: 58 (Darwent 5 for 14).
College: 214 for 4 wickets (Moss 77, retired, Darwent 54, retired, Miller 32, Jones 32).
Versus H.M.S. *Norfolk*. Drawn.
College: 116 (Manning 40).
H.M.S. *Norfolk*: 101 for 9 wickets (Jones 2 for 7).
Versus Queen's Park Cricket Club. Lost by 4 wickets.
College: 74 (Darwent 36 not out).
Queen's Park C.C.: 107 for 7 wickets.
Versus "Toco" Lost by 46 runs.
"Toco": 138 (McEwen 4 for 22).
College: 96 (Moss 48).
Versus The Staff. Won by 1 wicket.
The Staff: 98 (Jones 3 for 8).
College: 103 for 9 wickets (Moss 51 not out).
Versus Queen's Park Cricket Club. Lost by 89 runs.
Queen's Park C.C.: 138 for 6 wickets declared.
College: 49 (Jones 19).

TRINIDAD SCIENCE CLUB.

Three meetings of this Club were held at the College during the summer term.

Mr. D. D. Paterson gave an illustrated account of an agricultural officer's life in Iraq, a country where he served for several years before joining the Staff of the Imperial College of Tropical Agriculture. This lecture was greatly appreciated, particularly perhaps by the Post-Graduates, who attended in large numbers, as it gave them an insight into the sort of problems they are themselves likely to meet in their own careers.

In May, Mr. F. W. Urich, gave a short and most interesting account of fungus-growing ants. Some of his investigations have thrown new light on the history and habits of "parasol" ants of various types.

In June, Dr. O. Kaden addressed the Club on Cacao and Coffee Diseases in San Thomé. Dr. Kaden is the chief Scientific Officer of the Planters' Association of that Portuguese colony, and the illustrations by which he described his lecture proved of great interest to the scientific workers present and also to planters of these crops in this part of the world.

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ASSOCIATESHIP AWARDS.

The following Associateship Awards have recently been made:—

Mr. I. W. M. Armstrong-Black, B.Sc., Ph.D. (St. Andrews).
Mr. W. J. Badcock, N.D.A., Dip. Agric. (Reading).
Mr. J. A. Baker, B.Sc., A.R.C.S. (London).
Mr. J. E. P. Booth, B.Sc. Agric. (London).
Mr. D. H. Brown.
Mr. J. N. Clothier, Dip. Agric. (Wye).
Mr. W. T. Dalgarno, M.A., B.Sc. (Aberdeen).
Mr. R. E. T. Hobbs, Dip. Agric. (Reading).
Mr. W. J. M. Irving, B.Sc. (Edinburgh).
Mr. J. D. Jameson, B.A. (Oxon).
Mr. J. G. M. King, Dip. Agric. (Wye).
Mr. L. N. H. Larter, B.Sc., A.R.C.S. (London).
Mr. G. W. Lock, N.D.A., N.D.D., C.D.A. (Midland Agric. College).
Mr. A. F. Nichols.
Mr. G. D. P. Olds, B.Sc. Agric. (Reading).
Mr. E. Parry-Jones, B.Sc. (Wales), F.E.S.
Mr. E. O. Pearson, B.A. (Cantab.).
Mr. M. F. Rose, B.A. Hons. (Cantab.).
Mr. T. A. Russell, B.Sc., A.R.C.S. (London), Dip. Agric. (Cantab.).
Mr. F. A. Squire, B.Sc. (S. Africa), F.E.S.
Mr. H. B. Stent, M.Sc., A.I.C. (Manchester).
Mr. J. F. Williams.

AGRICULTURAL EXCURSIONS.

Post-Graduate Tours at Easter.

In accordance with the usual custom, tours were arranged for the Post-Graduates during the Easter vacation. The main party, conducted by Professor R. C. Wood and Mr. D. D. Paterson, consisting of seventeen students, made a tour of the Islands as far as St. Lucia and spent three days each in that island and Barbados, besides calling *en route* at Grenada and St. Vincent.

At St. Lucia, the Agricultural Superintendent, Mr. E. A. Walters, had arranged a strenuous and comprehensive programme which included visits to the Union Experimental Station, the Peasants' Bureau and Fruit Packing Shed, and tours to sugar and lime estates, with a trip to the fertile Souffriere district, where the view from the sea of the Pitons was greatly admired.

At Barbados, thanks to the arrangements of the Director of Agriculture, Mr. R. W. R. Miller, an opportunity was afforded of seeing something of the activities of the Agricultural Department. Particular interest was shown in the cane-breeding programme and in the attempts that are being made to control the cane borer (*Diatraea*) by biological means through the agency of *Trichogramma*.

Another party of six students, which was accompanied by the Principal, spent a week at St. Vincent. An instructive tour of the island was made, and such matters as the Sea Island cotton and the arrowroot industries were gone into in great detail. The efficient way in which the newly organised Arrowroot Pool is being managed was noted, and interest was also taken in the many problems, pathological as well as economic, that are being encountered in the newly formed industry of tomato growing for export. His Honour, the Administrator, Major H. H. Peebles, and the Staff of the Agricultural Department, were indefatigable in their endeavour to make the trip a success.

At Grenada, during the short time available, both parties were met by Mr. K. T. Rae, the Superintendent of Agriculture, who was good enough to show some of the work that is being done by his Department. His hospitality also was greatly appreciated.

Two students, who are specialising in soil science, visited British Guiana and completed a tour of about a week in the interior in company with Mr. R. R. Follett-Smith, the Chemist-Ecologist of the Agricultural Department. Thanks are due to him and to the Director of Agriculture, Professor J. S. Dash, for the kindness shown and the facilities given.

There is no doubt that these tours do a great deal of good, as they broaden the outlook of all concerned, and the numerous discussions that take place often bear fruitful results. In particular, they serve to put the students in touch with the realities of service and enable them to appreciate some of the difficulties, administrative and otherwise, that officers of Agricultural Departments have to face in their everyday work.

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OLD STUDENTS' CORNER.

J. Wright (1928-29), Gold Coast Department of Agriculture, has been transferred from Oda to Aburi.

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C. W. Lynn (1928-29) has been posted to Tamale (Gold Coast).

* * *

T. G. Strangeways (1930-31) has been posted to the Volta River District (Gold Coast).

* * *

W. F. Gwilliam (1930-31) has been posted to the Bekwai District (Gold Coast).

* * *

A. S. Thomas (1928-29) has been transferred from the Gold Coast to the Uganda Department of Agriculture, where he will act as Assistant Botanist.

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R. P. Davidson (1929-30) and A. J. Kerr (1929-30) have been appointed as officers under the Department of Agriculture, Uganda.

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J. V. Lochrie (1925-26) has been appointed to succeed Mr. MacDonald as Cotton Specialist, Swaziland.

* * *

J. E. Symond (1926-27) acted for six months as Assistant Director of Agriculture, Gold Coast.

* * *

T. L. Williams (1926-27) is married and returned in October to the Gold Coast where he will be engaged in cotton work.

* * *

J. D. Broatch (1927-28) is still stationed at the Training Centre, Kumasi, Gold Coast, and C. L. Skidmore (1927-28) is at Head Office, Accra, where he is doing the Publications and Meteorological Division's work.

Printed by the Government Printer, Trinidad, B.W.I.

CHEMICAL NOTES.

Compiled by the College Department of Chemistry and Soil Science.

Origin of Vitamin C.

Three Scandinavian workers, Ottar Rygh, Aagot Rygh and Per Laland, have obtained what appears to be conclusive evidence that narcotine, one of the less toxic alkaloids present in opium, is a, if not the, precursor of the antiscorbutic vitamin C. In the first issue of the *Zeitschrift fur Physiologische Chemie* for 1932, these authors describe how they found the alkaloid in various unripe fruits and vegetables, but failed to detect its presence in the ripened materials. From 200 unripe oranges they prepared 600 mgm. of the alkaloid; and by extracting the concentrate, consisting of oil and crystals, from 15,000 oranges at various stages of ripeness, they were able to trace the gradual increase in antiscorbutic power as ripening proceeded. Pure commercial narcotine was not antiscorbutic, but irradiation from a quartz mercury vapour lamp activated it to some extent without appreciably altering its physical properties. Guinea-pigs were fed on dietaries containing narcotine and irradiated narcotine; both groups died about the same time, but the former group developed strong signs of scurvy before dying and the latter none. Narcotine was found in unripe tomatoes (20 mgm. in 20 kgm.), white cabbage (40 mgm. in 100 kgm.), and in potatoes (12 mgm. in 20 kgm.); qualitative indications of the presence of narcotine were found in milk, but none in red bilberries. Of various derivatives of narcotine, the orthodihydroxy derivative—methylnornarcotine—was found to be particularly antiscorbutic. In presence of germinating seeds, known to produce vitamin C, narcotine became active; it disappeared and gave rise to phenols.—(*Nature*, Vol. CXXIX, No. 3251, 20th February, 1932, p. 283.)

* * *

Vitamin Content of the Mango.

The Empire Marketing Board has issued a publication entitled "Preliminary Report on the Vitamin Content of the Mango," by E. O. V. Perry and S. S. Zilva. The authors have examined three varieties of Indian mango, "Alphonso," "Carvasji Patel," and "Shendrya," for the vitamin content of the pulp. The "Alphonso" variety was tested for vitamins A and C in 1930, and for vitamins A, C, and D in 1931, in order to gain some idea of the seasonal variation. The other two varieties were tested for the three vitamins in 1931 only.

The results show that the pulp of the Alphonso variety is one of the most potent sources of vitamin C. The Carvasji Patel variety is slightly less active, but is as potent as the previously best known natural source. The Shendrya variety contains in comparison little vitamin C. One test carried out on the rind of the Alphonso variety showed that it contained at least as much vitamin C as the pulp.

The pulp of all three varieties contains vitamin A in quantities similar to that possessed by butter. The Alphonso variety is somewhat better than the other two varieties in this respect. No very significant amount of vitamin D was found in the pulp of any of the three varieties.

An important point in connection with this work is that the mangoes were sent from India to London by mail steamer, being kept at between 40° to 50°F. during the voyage. Thus the results are economically more significant than if the tests had been carried out on fresh fruit.

* * *

Spontaneous Heating and Ignition of Agricultural and Industrial Products.

In 1929 the National Fire Protection Association of the United States of America formed a committee to study the causes and means of prevention of spontaneous heating and ignition. Many theories have been advanced, but they have invariably failed to explain what takes place after the temperatures that will kill the known organisms have been reached. Recently C. A. Browne, of the Bureau of Chemistry and Soils, put forward an explanation of the development of heat beyond the temperature that might be created in the fermentation process. Dr. Browne's theory is based upon the idea that the micro-organisms develop unsaturated, highly unstable, intermediate fermentation products upon the surfaces of the porous cellular material under more or less perfect anaerobic conditions. These highly unstable compounds are readily oxidised with the generation of increasing quantities of heat, leading to the destruction of the organism, and eventually to the ignition of the vegetable matter.

The committee invite the co-operation of anyone who has information regarding tests which have been made, or fires which are known to have been caused by spontaneous combustion. The subject is of great economic importance, and further information may be obtained from H. H. Brown, Chairman, Committee on Spontaneous Heating and Ignition, 475 Fifth Avenue, New York.—(*Ind. and Engin. Chem.*, News Edition, Vol. IX, No. 24, p. 360.)

* * *

Formula and Synthesis of Vitamin C.

Before a recent meeting of the Norwegian Society of Science in Oslo, a young Norwegian chemist, Ottar Rygh, presented a report of his research work carried on for a couple of years and resulting in the discovery of the formula and constitution of vitamin C. This work has been conducted chiefly in the laboratory of the Norwegian drug firm, Nygaard & Co., and with its financial support. Ottar Rygh and his assistants not only have been able to prepare the actual vitamin C substance in pure crystalline form and to determine its empirical formula, but they have also succeeded in finding the composition formula of the substance and accomplishing its synthesis from the alkaloid narcotine of which the vitamin C substance is found to be a relatively simple derivative.—(*Ind. and Engin. Chem.*, News Edition, Vol. X, No. 1, 1932, p. 5.)

TREND OF THE MARKETS.

[*The notes below are based principally upon running charts of the prices of the basic grades and upon general statistical information gleaned from contemporary publications and cablegrams and are intended to be a record of movements. An attempt is made, where possible, to indicate the market outlook at the time of going to press, but no responsibility for the accuracy and subsequent truth of such observations is assumed. Unless otherwise stated the prices quoted are spot, London.*]

SUGAR.—Prices on the Home Market have ranged as follows (c.i.f. per cwt.) :—

	Foreign. s. d.	*Preferential.* s. d.
28th April ..	4 6	9 3
5th May ..	4 3¾	9 0
12th May ..	4 7½	9 4½
19th May ..	4 8¼	9 6
26th May ..	4 6	9 3
2nd June ..	4 6	9 3
9th June ..	4 9	9 6
12th June (1931)	6 4½	10 1½

Although the market has remained quiet, prices have remained fairly steady with a slight tendency to rise. Holders are showing a more determined resistance to further declines in prices.

* * *

COCOA.—During the past month markets abroad have been unusually quiet and prices have declined still further and the prospective supply and demand position of cocoa, for example, hardly warrants present prices, let alone still lower values. Yet, if manufacturers are discouraged by prevailing world conditions from replenishing conservative reserves, but adopt a policy of buying from hand to mouth, the likelihood develops that the new crops of Bahia and Sanchez during the next four months as well as the new West African crops, beginning in October, will depress already low prices still further. Fair Fermented Accra has been quoted at 28*s.* to 29*s.* whilst in Trinidad $6.50 a fanega is generally paid.—(*By courtesy of the Cocoa Planters' Association of Trinidad, Limited.*)

* * *

RUBBER.—Quotations for Plantation Sheet have ranged as follows :—

	d.
27th April	1 15/16
4th May	2
11th May	2
18th May	1 15/16
25th May	1 13/16
1st June	1¾
8th June	1¾
5th June (1931)	3 1/8

An announcement was made at the beginning of May that the Senate Finance Committee of the United States of America had recommended an import duty of 5 or 10 cents on rubber. This proposal was calculated to yield $50,000,000 a year at the lower rate of duty, and was intended as a revenue, rather than a tariff, measure. The result was active buying by United States of America interests for immediate delivery, in order to escape the new tax, particularly as several of the larger manufacturers are believed to be carrying small stocks. A large quantity of rubber for prompt shipment was sold to New York, and prices ranged up to 2 3/16*d.* per lb. spot. Subsequently this proposed tax on raw rubber was abandoned and an excise, or sales, tax on tyres of 3 cents per lb. and on tubes of 5 cents per lb. was advanced as a substitute. The advances in prices were immediately lost, and although London stocks were reduced by over 4,000 tons, a considerable proportion of the shipments was cancelled. It is anticipated that the abandonment of all idea of "restriction" will improve the production aspect by eliminating considerable areas. The market is now dull and inactive.

* * *

COTTON.—The following are the official spot prices in pence per lb., of the Liverpool Cotton Association :—

	American Mid.	*Egyptian F.G.F. Sakel.*
29th April ..	4.82	6.55
6th May ..	4.53	6.10
13th May ..	4.58	6.20
20th May ..	4.53	—
27th May ..	4.41	—
4th June ..	4.11	—
10th June ..	4.18	—
12th June (1931) ..	4.75	7.55

The market has been quiet and sales moderate. Prices have fluctuated within narrow limits despite the bearishness of the statistical position. Political influences have not tended to inspire confidence and the market remains apathetic. Weather conditions in the cotton belt are favourable but any changes may be expected to exert important influence on price movements.

* * *

BANANAS.—Bananas have been in improved demand, and prices are higher on the average. Jamaicas are now being sold at £20 5*s.* 0*d.*, delivered London, and £20 nearest railway station, and Brazilians at £18 per ton delivered nearest railway station.—(*West India Committee Circular*, 26th May.)

* * *

COPRA.—Copra is quiet and 7*s.* 6*d.* per ton lower at £14 17*s.* 6d., buyers c.i.f. London.—(*West India Committee Circular*, 26th May.)

* * *

COFFEE.—Considerable irregularity has prevailed but generally good to fine qualities have continued in good demand. Jamaican Blue Mountain averaged 200*s.*, Costa Rica Good 135*s.*, Kenya Good 100*s.* There have been few arrivals of Brazil and the price is nominal. Poorer qualities have been sold only at further concessions in price.

* * *

TEA.—Averages on May 25th, were : Ceylon 16.53*d.*, Indian 9.53*d.*, and Java 7.71*d.* per lb. These represent a decline from 27th April, due to the anxiety to dispose of inferior 1930-31 season tea,